DEPARTMENT OF DEFENSE

DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS

26 July 2002 (Last Update)

Under Secretary of Defense
for Acquisition,Technology & Logistics

DDESB WORKING COPY

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

ACQUISITION AND TECHNOLOGY

FOREWORD

0 1 JUL 1999

This Standard is issued under the authority of DoD Directive 6055.9, "DoD Explosives Safety Board (DDESB), and DoD Component Explosives Safety Responsibilities," July 29, 1996. It establishes uniform safety standards applicable to ammunition and explosives, to associated personnel and property, and to unrelated personnel and property exposed to the potential damaging effects of an accident involving ammunition and explosives during their development, manufacturing, testing, transportation, handling, storage, maintenance, demilitarization, and disposal.

DoD 6055.9-STD, "Ammunition and Explosives Safety Standards," August 11, 1997 is hereby canceled. This Standard applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, and the Defense Agencies (hereafter referred to collectively as "DoD Components").

This Standard is effective immediately and is mandatory for use by all DoD Components. The heads of the DoD Components may issue supplementary instructions only when necessary to provide for unique requirements within their respective Components. A copy of supplementary instructions shall be forwarded to the Chairman, DDESB.

Forward recommendations for change to this Standard through channels to:

Chairman
Department of Defense Explosives Safety Board
246 1 Eisenhower Avenue
Alexandria, VA 2233 1-0600

This Standard is only available in electronic form. The DoD Components, other Federal Agencies and the public may obtain copies from the Washington Headquarters Services Directives and Records Branch (Directives Section) on the worldwide web at http://web7.whs.osd.mil/corres.htm. Reports Control Symbols DD-A&T (AR) 1643 and DD-A&T (AR) 1020 have been assigned to the reports required by this Standard.

J. S. Gansler

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REFERENCES

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(Added by 322nd Board Meeting)

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ABBREVIATIONS AND/OR ACRONYMS

AA&E	Arms, Ammunition and Explosives
AEL	airborne exposure limits
ASU	*ammunition storage unit*
BLAHA	basic load ammunition holding area
CB	chemical/biological
CBU	cluster bomb unit
CCI	*Controlled Cryptographic Items*
CE	*conditional exemption, civil engineer*
CG	compatibility group
C*o*E	Corps of Engineers
CONUS	continental United States
DDESB	Department of Defense Explosives Safety Board
D*o*DAC	Department of Defense ammunition code
D*o*T	Department of Transportation
DPE	demilitarization protective ensemble
DTA	differential thermal analysis
DUSD(ES)	Deputy Under Secretary of Defense (Environmental Security)
ECM	earth-covered magazine
EED	electroexplosive device
EIDS	extremely insensitive detonating substances
EMR	electromagnetic radiation
EOD	explosive ordnance disposal
EPA	*Environmental Protection Agency*
EPCRA	*Emergency Planning Community-Right -To-Know Act*
ES	exposed site
FAE	fuel-air explosives
FSC	Federal supply class
FUDS	formerly used defense sites
GSA	General Services Administration
HAS	hardened aircraft shelter
HC	hexachlorethane
HE	high explosive
HMP	*High Performance Magazine (Added 319th Board Meeting)*
IAW	in accordance with
IBD	inhabited building distance
ILD	intraline distance
IMD	intermagazine distance
IMO	International Maritime Organization
IPS	inches per second
ISO	International Standardization Organization
JHCS	Joint Hazard Classification System
LEPC	*Local Emergency Planning Committees*
LOX	liquid oxygen

MCE	maximum credible event
MILVANS	military vans
Mk	Mark
Mod	Model
MPS	maritime pre-positioning ships
MR	munitions rule
MSHA	Mine Safety and Health Administration
MWD	military working dogs
MWR	morale, welfare, and recreation
NALC	navy ammunition logistic code
NATO	North Atlantic Treaty Organization
NEQ	net explosive quantity
NEW	net explosive weight
NIN	National identification number
NIOSH	National Institute Occupational Safety and Health
NSN	National stock number
PES	potential explosion site
PETN	pentaerythritol tetranitrate
POL	petroleum, oils, lubricants
POTMC	protective outfit toxicological microclimate controlled
PPE	personnel protection equipment
PSI	pounds per square inch
PTR	public traffic route
PWP	plasticized white phosphorus
Q-D	quantity-distance
R&R	rest & recreation
RCRA	*Resource Conservation and Recovery Act*
RDT&E	research, development, test and evaluation
RDX	cyclonite
SCBA	self-contained breathing apparatus
SOP	*standard operating procedure*
TAPES	toxicologic agent protective ensemble, self-contained
TEA	triethyl aluminum
TNT	trinitrotoluene
TWA	time weighted average
UNO	United Nations Organization
UXO	unexploded ordnance
WP	white phosphorus

C1. CHAPTER 1 INTRODUCTION

C1.1. POLICY

It is DoD policy consistent with operational requirements to:

C1.1.1. Provide the maximum possible protection to personnel and property, both inside and outside the installation, from the damaging effects of potential accidents involving DoD ammunition and explosives.

C1.1.2. Limit the exposure of a minimum number of persons, for a minimum time, to the minimum amount of ammunition and explosives consistent with safe and efficient operations.

C1.1.3. Comply with these ammunition and explosives safety standards. When DoD ammunition and explosives are located in overseas areas, comply with U.S. ammunition and explosives safety standards except when compliance with more restrictive local standards is made mandatory by an appropriate international agreement. When such ammunition is not in U.S. custody and under U.S. control, comply with U.S. standards to the extent consistent with agreements or arrangements with the host country concerned.

C1.2. SCOPE

C1.2.1. Ammunition and explosives safety standards herein shall be considered minimum and greater protection shall be afforded when practicable. They apply whenever any explosives, propellants, or similar energetic materials are present on DoD-owned or -leased facilities and to U.S.-titled ammunition in host nation facilities.

C1.2.2. Standards herein shall govern DoD facilities siting and construction except:

C1.2.2.1. When facilities already have been constructed or approved for construction to meet plans that were developed before the date of this Publication.

C1.2.2.2. Existing facilities that do not comply with these standards (when current hazards are not greater than those assumed for their original use) shall be allowed for the balance of their useful lives when it can be demonstrated clearly that redesign or modification is not feasible, and that the quantity of explosives, propellants, or chemical agents cannot be reduced for reasons of operational necessity.

C1.2.2.3. Planned facilities that do not meet these standards, but have been certified by the head of the DoD Component as essential because of operational necessity or other compelling reasons.

C1.2.2.4. Other situations that upon analysis by the DoD Component and the DoD Explosives Safety Board (DDESB) are determined to provide the required degree of safety through use of protective construction or other specialized safety features.

C1.2.3. The excepted deviations from these standards in subsection C1.2.2., above, must be documented in the permanent records of the installation. This document must show the date the applicable standard was first published and the date the deviant facility was approved for safety or was first used in the deviating manner.

(Added after the 319th Board Meeting)

C1.2.4. Evaluate non-DoD explosives siting submissions on DoD installations only to insure compliance with DoD explosives safety standards to non-commercial (DoD) exposures and in accordance with Table C5.T4.

C1.3. DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS WAIVER AND EXEMPTION PROGRAM

C1.3.1. **General.** The ammunition and explosives safety standards herein are designed to *manage the risks associated with ammunition and explosives* by *providing* protection against serious injury, loss of life, and damage to property but are not intended to be so rigid as to prevent the DoD Components from accomplishing their assigned missions. Consequently, when deviating from these standards, proper authority within the DoD Component must accept the added risk to personnel and property against the strategic and other compelling reasons that necessitate such deviations. *That added risk to personnel and property must be analyzed and documented to include methods used to reduce the risk to a level acceptable to the DoD Component approval authority.*

C1.3.1.1. A waiver is written authority that permits temporary deviation from a mandatory requirement of these standards for strategic or other compelling reasons. Generally, it is granted for a short period pending cancellation or correction of the waived conditions. Waivers will not be granted for periods exceeding 5 years. Exceptional situations may require time for completion of corrective action or actions that exceed 5 years, in which case the waiver shall be reissued by the next higher approval authority unless the waiver was last issued at the Military Service head level. Waivers may be granted by the official with (1) assigned responsibilities consistent with the level of risk and (2) the authority to control the resources required to accomplish corrective action. Waivers will be reviewed for applicability and currency at intervals not exceeding 2 years.

C1.3.1.2. An exemption is written authority that permits long term noncompliance with these standards for strategic or other compelling reasons. Exemptions may be granted by law, by congressional action, or by appropriate military authority. Appropriate military authority shall be that official with assigned responsibilities consistent with the level of risk. Exemptions shall be reviewed for applicability and currency at intervals not to exceed 5 years.

C1.3.1.3. Secretarial Exemption/Certification is authority granted by the Service Secretary to deviate from the requirements of this Standard for existing situations or allow new potential explosion sites and/or new exposed sites. These must be reviewed at intervals not to

exceed five years to validate strategic or compelling operational requirements and ensure the identification of risks and exposures.

C1.3.2. **Information Requirements**. Upon request, DoD Components shall provide the DDESB with the following information (as applicable) on exemptions and waivers granted to the standards contained herein and any changes thereto. This reporting requirement has been assigned Report Control Symbol DD-A&T(AR)1643 in accordance with DoD 8910.1-M (reference (a)).

C1.3.2.1. Identification number (DoD Component-derived) and classification (waiver or exemption in accordance with classification procedure cited in paragraphs C1.3.1.1. and C1.3.1.2., above).

C1.3.2.2. Location and condition waived or exempted.

C1.3.2.2.1. Total explosive weight by hazard classification/division at a potential explosion site (PES).

C1.3.2.2.2. Distance to exposed site or sites (ES) from PES and brief description of ES to include type and estimated value of property and whether property is located on or off installation.

C1.3.2.2.3. Estimated number of personnel on and off the installation located at the ES.

C1.3.2.2.4. Calculated public access exclusion distance.

C1.3.2.3. Date of approval, expiration, or cancellation as appropriate and title of approving authority.

C1.3.2.4. Planned corrective action with date of expected completion.

C1.3.2.4.1. Estimated cost to correct.

C1.3.2.4.2. Military construction project number, if assigned.

C2. CHAPTER 2 EFFECTS OF EXPLOSIONS AND PERMISSIBLE EXPOSURES

C2.1. INTRODUCTION

In the assessment of the hazard associated with a given situation, the principal effects of the explosive output to be considered are blast pressure, primary and secondary fragments, thermal hazards, and chemical agent hazards. In this Chapter the effects of these hazards and permissible exposures are detailed.

C2.2. BLAST PRESSURE OUTPUT

C2.2.1. **Blast Wave Phenomena.** The violent release of energy from a detonation in a gaseous medium gives a sudden pressure increase in that medium. The pressure disturbance, termed the blast wave, is characterized by an almost instantaneous rise from the ambient pressure to a peak incident pressure (Pso). This pressure increase, or shock front, travels radially from the burst point with a diminishing velocity that always is in excess of the sonic velocity of the medium. Gas molecules making up the front move at lower velocities. This latter particle velocity is associated with a "dynamic pressure," or the pressure formed by the winds produced by the shock front.

C2.2.1.1. As the shock front expands into increasingly larger volumes of the medium, the peak incident pressure at the front decreases and the duration of the pressure increases.

C2.2.1.2. If the shock wave impinges on a rigid surface oriented at an angle to the direction of propagation of the wave, a reflected pressure is instantly developed on the surface and the pressure is raised to a value that exceeds the incident pressure. The reflected pressure is a function of the pressure in the incident wave and the angle formed between the rigid surface and the plane of the shock front.

C2.2.2. **Partially Confined Explosions.** When an explosion occurs within a structure, the peak pressure associated with the initial shock front will be extremely high and, in turn, will be amplified by reflections within the structure. In addition, the accumulation of gases from the explosion will exert additional pressures and increase the load duration within the structure. The combined effects of both pressures eventually may destroy the structure if it is not strengthened sufficiently or adequate venting for the gas and the shock pressure is not provided, or both. For structures that have one or more strengthened walls, venting for relief of excessive gas or shock pressures, or both, may be provided by means of openings in or frangible construction of the remaining walls or roof, or both. This type of construction will permit the blast wave from an internal explosion to spill over onto the exterior ground surface. These pressures, referred to as exterior or leakage pressures, once released from their confinement, expand radially and act on structures or persons, or both, on the other side of the barrier.

C2.3. EXPECTED EFFECTS - HAZARD DIVISION 1.1

C2.3.1. **Conventional Structures.** Conventional structures are designed to withstand roof snow loads of 30 pounds per square foot (1.44 kilopascals) and wind loads of 100 miles per hour (161 kilometers per hour). The loads equate to 0.2 pounds per square inch (psi). Airblast overpressure at Hazard Division 1.1 barricaded intraline distance is 12 psi (82.7 kPa); at unbarricaded intraline distance is 3.5 psi (24 kPa); and at inhabited building distance is 0.9 to 1.2 psi (6.2 to 8.3 kPa). Comparing these loads with the design capacity, it is evident that conventional buildings will be damaged even at inhabited building distance. Conventional structures, which include aboveground storage facilities, contribute little to propagation protection from either blast or fragments. Propagation protection is provided by distance and/or barricading. The amount of damage to be expected at various pressure levels is described below.

C2.3.2. **Earth-Covered Magazines.** The earth-covered magazines identified in section C5.2., Chapter 5, separated one from another by the minimum distances required by Table C9.T5., provide virtually complete protection against propagation of explosion by blast, fragments, and fire; however, there may be some cracking of concrete barrels and rear walls, possible severe cracking and some spalling of front walls, and some damage to doors and ventilators.

C2.3.3. **Underground Storage Facilities.** Underground facilities sited and constructed as specified in section C9.7., Chapter 9 provide a high degree of protection against propagation of explosion between chambers by blast, fragments or spall, and between underground and aboveground structures. Delayed propagation between chambers by fire is possible, but this possibility may be minimized by installation of a fire suppression system.

C2.3.4. **Barricaded Open-Storage Modules.** Barricaded open-storage modules (paragraph C5.2.2., Chapter 5) provide a high degree of protection against propagation of explosion by blast and fragments. However, if flammable materials are present in nearby cells, subsequent propagation of explosion by fire is possible. Items at K=1.1 separations from a donor explosion will be covered with earth and unavailable for use until extensive uncovering operations and possibly maintenance are completed. Items at K=2.5 separations are expected to be readily accessible.

(Approved at 319th Board Meeting)

C2.3.5. High Performance Magazines. The high performance magazine (HPM) identified in section C5.2.4., Chapter 5, with the minimum intermagazine separation distances required by Table C9.T5, provides virtually complete protection against propagation of explosion by blast, fragments, and fire. The story-2 transfer area is enclosed by pre-engineered metal building which may be severely damaged. The amount of damage to be expected at various pressure levels is described below. Unless special design requirements are imposed, access to ammunition items at less than K30 from a donor explosion require extensive cleanup and mobile crane.

C2.3.6. **Barricaded Aboveground Magazine Distance - $6W^{1/3}$ ft ($2.4Q^{1/3}$m) - 27 psi (186.1 kPa)**

C2.3.6.1. Unstrengthened buildings will be destroyed completely.

C2.3.6.2. Personnel at this distance or closer will be killed by direct action of blast, by being struck by building debris, or by impact against hard surfaces.

C2.3.6.3. Transport vehicles will be overturned and crushed by blast.

C2.3.6.4. Explosives loaded vessels will be damaged severely, with propagation of explosion likely.

C2.3.6.5. Aircraft will be destroyed by blast, thermal, and debris effects.

C2.3.6.6. **Control.** Barricades are effective in preventing immediate propagation of explosion by low angle fragments, but provide only limited protection against delayed propagation of explosion caused by fire resulting from high angle firebrands.

C2.3.7. **Barricaded Intraline Distance - $9W^{1/3}$ ft ($3.6Q^{1/3}$m) - 12 psi (82.7 kPa)**

C2.3.7.1. Unstrengthened buildings will suffer severe structural damage approaching total destruction.

C2.3.7.2. Severe injuries or death to occupants of the ES may be expected from direct blast, building collapse, or translation.

C2.3.7.3. Aircraft will be damaged beyond economical repair both by blast and fragments. If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.

C2.3.7.4. Transport vehicles will be damaged heavily, probably to the extent of total loss.

C2.3.7.5. Direct propagation of explosion between two explosives locations is unlikely when barricades are interposed between them to intercept high velocity low angle fragments.

C2.3.7.6. Improperly designed barricades or structures may increase the hazard from flying debris, or may collapse in such a manner as to increase the risk to personnel and equipment.

C2.3.7.7. **Control.** Barricading is required. Exposed structures containing equipment of high monetary value or of critical mission importance or wherein personnel exposure is significant may require hardening for necessary protection of personnel and equipment.

C2.3.8. **Unbarricaded Aboveground Magazine Distance - $11W^{1/3}$ ft ($4.4Q^{1/3}$m) - 8 psi (55.3 kPa)**

C2.3.8.1. Unstrengthened buildings will suffer damage approaching total destruction.

C2.3.8.2. Personnel are likely to be injured seriously due to blast, fragments, debris, and translation.

C2.3.8.3. There is a 20-percent risk of eardrum rupture.

C2.3.8.4. Explosives loaded vessels are likely to be damaged extensively and delayed propagation of explosion may occur.

C2.3.8.5. Aircraft will be damaged heavily by blast and fragments; destruction by ensuing fire is likely.

C2.3.8.6. Transport vehicles will sustain severe body damage, minor engine damage, and total glass breakage.

C2.3.8.7. **Control.** Barricading will reduce significantly the risk of propagation of explosion and injury of personnel by fragments.

C2.3.9. **Unbarricaded Intraline Distance - $18W^{1/3}$ ft ($7.2Q^{1/3}$m) - 3.5 psi (24 kPa)**

C2.3.9.1. Direct propagation of explosion is not expected.

C2.3.9.2. There is some possibility that delayed communication of an explosion may occur from fires, or as a result of equipment failure at the ES.

C2.3.9.3. Damage to unstrengthened buildings will be of a serious nature and approximately 50 percent or more of the total replacement cost.

C2.3.9.4. There is a 1-percent chance of eardrum damage to personnel.

C2.3.9.5. Personnel injuries of a serious nature are likely from fragments, debris, firebrands, or other objects.

C2.3.9.6. Cargo ships would suffer damage to decks and superstructure from being struck by fragments and having doors and bulkheads on the weather deck buckled by overpressure.

C2.3.9.7. Aircraft can be expected to suffer considerable structural damage from blast. Fragments and debris are likely to cause severe damage to aircraft at distances calculated from the formula $18W^{1/3}$ when small quantities of explosives are involved.

C2.3.9.8. Transport vehicles will incur extensive, but not severe, body and glass damage consisting mainly of dishing of body panels and cracks in shatter-resistant window glass.

C2.3.9.9. **Control**. Many situations arise in which control of pressure by suitably designed suppressive construction at the PES or protective construction at the ES are practical. Use of such construction to withstand blast overpressure is encouraged if it is more economical

than distance alone, or if sufficient distance is not available to prevent the overpressure from exceeding this level.

C2.3.10. **Public Traffic Route Distance (under 100,000 lbs HE) $24W^{1/3}$ ft ($9.6Q^{1/3}$m) - 2.3 psi (15.8 kPa)**

C2.3.10.1. Unstrengthened buildings can be expected to sustain damage approximately 20 percent of the replacement cost.

C2.3.10.2. Occupants of exposed structures may suffer temporary hearing loss or injury from secondary blast effects such as building debris and the tertiary effect of displacement.

C2.3.10.3. Personnel in the open are not expected to be killed or seriously injured directly by blast. There may be some personnel injuries caused by fragments and debris, depending largely upon the PES structure and amount of ammunition and fragmentation characteristics thereof.

C2.3.10.4. Vehicles on the road should suffer little damage unless hit by a fragment or unless the blast wave causes momentary loss of control.

C2.3.10.5. Aircraft should suffer some damage to appendages and sheet metal skin from blast and possible fragment penetration; however, the aircraft should be operational with minor repair.

C2.3.10.6. Cargo-type ships should suffer minor damage to deck structure and exposed electronic gear from blast and possible fragment penetration, but such damage should be readily repairable.

C2.3.10.7. **Control**. The risk of injury or damage due to fragments for limited quantities of explosives at the PES can be reduced by barricading. Also, many situations arise when control of pressure by suitably designed suppressive construction at the PES or protective construction at the ES are practical.

C2.3.11. **Public Traffic Route Distance (over 250,000 lbs HE) $30W^{1/3}$ ft ($12Q^{1/3}$m) - 1.7 psi (11.7 kPa)**

C2.3.11.1. Unstrengthened buildings can be expected to sustain damage approximately 10 percent of the replacement cost.

C2.3.11.2. Occupants of exposed unstrengthened structures may suffer injury from secondary effects such as building debris.

C2.3.11.3. Aircraft in landing and takeoff status may lose control and crash.

C2.3.11.4. Parked military and commercial aircraft likely will sustain minor

damage due to blast but should remain airworthy.

C2.3.11.5. Personnel in the open are not expected to be killed or seriously injured directly by blast. There may be some personnel injuries caused by fragments and debris, depending largely upon the PES structure and amount of ammunition and fragmentation characteristics thereof.

C2.3.11.6. **Control.** The risk of injury or damage due to fragments for limited quantities of explosives at the PES may be reduced by barricading or application of minimum fragment distance requirements.

C2.3.12. **Inhabited Building Distance $40W^{1/3}$ ft - $50W^{1/3}$ ft ($16Q^{1/3}$ - $20Q^{1/3}$m) - 1.2 psi - 0.90 psi (8.3 kPa - 6.2 kPa)**

C2.3.12.1. Unstrengthened buildings can be expected to sustain damage up to about 5 percent of the replacement cost.

C2.3.12.2. Personnel in buildings are provided a high degree of protection from death or serious injury, with injuries that do occur principally being caused by glass breakage and building debris.

C2.3.12.3. Personnel in the open are not expected to be injured seriously directly by the blast. There could be some personnel injuries caused by fragments and debris, depending largely upon the PES structure and amount of ammunition and the fragmentation characteristics thereof.

C2.3.12.4. **Control.** Glass breakage and structural damage can be reduced by means such as orientation, by keeping the surface area of exposed glass panels to a minimum and the use of blast-resistant windows.

C2.3.13. **Airblast Effects on Personnel.** The following describes airblast over-pressure effects to personnel.

Effect	Dose (psi)
1 percent Eardrum Rupture	3.4
50 percent Eardrum Rupture	16
Threshold Lung Rupture	10 (50 msec duration) 20-30 (3 msec duration)
1 percent Mortality	27 (50 msec duration) 60-70 (3 msec duration)

C2.4. PERMISSIBLE EXPOSURES TO AIRBLAST OVERPRESSURE – HAZARD DIVISION 1.1

C2.4.1. **12 psi (82.7 kPa) at $9W^{1/3}$ ($3.6Q^{1/3}$).** (Barricading is required.)

C2.4.1.1. Buildings housing successive steps of a single production, renovation, or maintenance operation.

C2.4.1.2. Security alert force buildings.

C2.4.1.3. Facilities of a tactical missile site where greater distances from the PES cannot be provided for technical reasons.

C2.4.1.4. Breakrooms and change houses if they are part of an operating line and are used exclusively by personnel employed in operations of the line.

C2.4.1.5. Temporary holding areas for trucks or railcars containing explosives to service production or maintenance facilities.

C2.4.1.6. Field operations in magazine areas when performing minor maintenance, preservation, packaging, or surveillance inspection.

C2.4.1.7. Unmanned auxiliary power facilities, transformer stations, water treatment and pollution abatement facilities, and other utility installations that serve the PES and are not an integral function in the PES, and loss of which would not create an immediate secondary hazard. These applications need not be barricaded. Exception: Unmanned auxiliary power generation or conversion facilities exclusively supplying power to the explosive storage area and security fence lighting may be located at fire protection distance from explosive facilities (50 feet for fire-resistant structures, 100 feet for nonfire-resistant structures).

C2.4.1.8. Dunnage preparation and similar support structures housing non-explosives operations if used only by personnel employed at the PES.

C2.4.1.9. Service magazines that are part of operating lines. Distances are based on the quantity and type of ammunition or explosives in the service magazine or magazines, not the operating building.

C2.4.1.10. Exposures as indicated in the next paragraph if blast suppression and structure hardening provide comparable protection for personnel and equipment involved.

C2.4.2. **3.5 psi (24 kPa) at $18W^{1/3}$ ($7.2Q^{1/3}$)**

C2.4.2.1. Surveillance, maintenance, and inspection buildings and labor intensive operations closely related to the PES.

C2.4.2.2. Comfort, safety, and convenience occupied buildings exclusively in support of the PES (such as lunchrooms, motor pools, area offices, auxiliary fire stations, transportation dispatch points, and shipping and receiving buildings (not magazine area loading docks)).

C2.4.2.3. Parallel operating lines from one another, whether or not barricaded,

provided ammunition and explosives involved in each operating line present similar hazards. The criticality or survivability of one or more of the operating lines may require that each line be given an inhabited building level of protection.

C2.4.2.4. Operations and training functions that are manned or attended exclusively by personnel of the unit operating the PES. This includes day rooms, squadron operation offices, and similar functions for units such as individual missile firing batteries, aircraft squadrons, or ammunition supply companies. Training functions permitted this level of exposure (3.5 psi) include organized classroom and field training of personnel who may be required to engage in explosives work at the PES. Maneuver areas, proving ground tracks, and similar facilities for armored vehicles also may be exposed to 3.5 psi (24 kPa) since the vehicle should provide adequate protection to the operators from fragments and debris.

C2.4.2.5. Maintenance of military vehicles and equipment when the PES is basic load or ready storage located outside the continental United States (OCONUS) areas, and is limited to 8,820 lb (4,000 kg) or less net explosive quantity (NEQ) at each and when the maintenance work is performed exclusively by and for military personnel of the unit for which the basic load of ammunition is stored.

C2.4.2.6. Auxiliary power and utilities functions excluding "cold-iron" facilities, supply, and mechanical support at naval station waterfront areas when not continuously manned, when serving only the waterfront area, and when the PES is a ship or ammunition handling location on the waterfront. This category includes auxiliary power plants; compressor stations; electric power transformers; tool and consumable supplies storage and issue; and handling equipment service, battery charging, and minor repair. When such facilities serve an entire naval station or base complex, or when loss of the facility will cause an immediate loss of vital function, the exposure level must not exceed 1.2 psi (8.3 kPa).

C2.4.2.7. Minimum distance between separate groups of explosives loaded combat-configured aircraft or between aircraft and a pre-load or "quick-turn" site that serves to arm the aircraft. The use of intervening barricades is required to reduce further communication and fragment damage and eliminate the necessity for totaling net explosive weight (NEW). Loading ammunition and explosives aboard aircraft can be accomplished with each group of aircraft without additional protection.

C2.4.2.8. Service magazines that are part of operating lines. Distances are based on quantity and type of ammunition or explosives in the service magazines, not the operating building.

C2.4.2.9. Container stuffing and unstuffing operations that are routine support of PES. This applies only to main support functions set aside for support of ship-loading or manufacturing operations. When the activity is in connection with ship-loading and unloading and the ES is an ammunition ship, the quantity at the container site shall govern. (Container stuffing and unstuffing in a magazine area are permitted at intermagazine distances.)

C2.4.2.10. Between explosive-loaded combat aircraft and those nonexplosives

facilities that directly support the servicing and launching of a unit's armed aircraft (that is, activities and their operating facilities that handle ammunition and explosives on the flightline, prepare and service armed aircraft, and those that fly combat aircraft). Direct flightline combat aircraft associated facilities may contain field offices, breakrooms, unit training rooms, and equipment and supply rooms, as well as petroleum, oils, lubricants (POL) hydrant facilities and civil engineer (CE) fire protection stations. Specifically excluded are morale, welfare, and recreation (MWR) facilities; base civil engineering headquarters; industrial facilities, including central base supply.

C2.4.3. **2.3 psi (15.8 kPa) at $24W^{1/3}$ ($9.6Q^{1/3}$).** Personnel exposed to remotely controlled operations.

C2.4.4. **2.3-1.7 psi (15.8-11.7 kPa) at 24-$30W^{1/3}$ (9.6-$12Q^{1/3}$)**

C2.4.4.1. Public traffic routes with medium and low traffic densities as described in subparagraphs C2.5.2.3.3.2. and C2.5.2.3.3.3., below.

(Changed by correspondence July 5, 2000)

C2.4.4.2. On-base roads. DoD Components may provide installation-related personnel, transiting the ESQD arc of munitions areas, protection less than 60 percent of IBD, provided the risks are evaluated, documented and per Component-established procedures. When Services determine such to be necessary, they should consider use of methods to inform transients of potential risks (e.g., written acknowledgement of the risk, by vendors or others with a recurring need to transit the ESQD, warning signs, flashing lights, physical barriers, etc.). The DoD Component's decision to provide transients protection at less than 60 percent of IBD must be:

C2.4.4.2.1. Supported by a qualitative risk assessment considering factors such as:

(1) Operational necessity .

(2) The operation being performed (e.g., static storage, maintenance, and production).

(3) Operational activity cycles.

(4) Alternate routes.

(5) Traffic density.

(6) Accident records.

(7) Time interval of exposure.

(8) Type and quantity of munitions in proximity to the area transited.

(9) The closest distance from the area transited to the PES.

(10) The need for installation-related personnel to transit the ESQD arc.

C2.4.4.2.2. Reviewed as changes occur to either operations, which would increase the explosive safety risk, or the number of exposed, and upon change of the approving authority.

> *Note: Effective 1 October 2000*, all new construction of *ammunition and explosives storage and operating facilities, and any change in operations within existing facilities that increases the explosive safety risk should provide both the general public and installation-related personnel who are not involved in munitions-related operations protection equal to or greater than 60 % of IBD.*

C2.4.4.3. Open air recreation facilities where structures are not involved (such as ball diamonds and volleyball courts) used for moral and health purposes at posts, camps naval stations, air bases, and other operational military activities. When recreation facilities solely are for off duty military personnel at their posts of duty, neither blast nor fragment Q-D apply. This total relaxation of Q-D requirements applies only when the PES and the ES are related closely as with a security alert force and explosives facilities for which they are responsible. It is not intended that this relaxation be used to encourage the building of elaborate installations that substitute for properly located R&R facilities or that they encourage the collocation of essentially unrelated military functions.

C2.4.4.*4*. Training areas for unprotected military personnel. They include observation points and instruction areas for small arms and artillery firing ranges and similar fixed facilities, including small classrooms, designed for occasional use coincident with use by groups or classes using the range. The separation or other protection is required from permanent magazines and ammunition supply points but not from that ammunition and explosives needed for any particular exercise in order to achieve realism in training nor from explosives in necessary on-the-job training operations for explosives workers.

C2.4.4.*5*. Aircraft passenger loading and unloading areas that do not include any structures.

C.2.4.5. **1.7 psi (11.7 kPa) at $30W^{1/3}$ ($12Q^{1/3}$).** Combat aircraft parking areas exposed to ammunition and explosive storage and operating facilities.

C2.4.6. **1.2 - 0.90 psi (8.3 - 6.2 kPa) at $40\text{-}50W^{1/3}$ ($16\text{-}20Q^{1/3}$)**

C2.4.6.1. Inhabited buildings, administrative and housing areas.

C2.4.6.2. Installation boundaries, unless manifestly inapplicable (unsuitable terrain, government land not open to the public, and so forth). For locations where installation boundary lines are penetrated by inhabited building Q-D arcs, the Service shall certify that conditions do not exist for the application of inhabited building protection to the encumbered area and shall establish procedures to monitor the area for any change in that status.

C2.4.6.3. Athletic fields and other recreation areas when structures are present.

C2.4.6.4. Flight-line passenger service functions.

C2.4.6.5. Main power houses providing vital utilities to a major portion of an installation.

C2.4.6.6. Storehouses and shops that by reason of their vital strategic nature, or high intrinsic value of their contents, should not be placed at risk.

C2.4.6.7. Functions that, if momentarily put out of action, would cause an immediate secondary hazard by reason of their failure to function.

C2.4.6.8. Public traffic routes with high traffic density as described in subparagraph C2.5.2.3.3.1., below.

C2.5. **FRAGMENTS**

C2.5.1. **General**

C2.5.1.1. An important consideration in the analysis of the hazard associated with an accidental explosion is the effect of the fragments generated by the explosion. These fragments are known as primary or secondary fragments depending on their origin.

C2.5.1.2. Primary fragments are formed as a result of the shattering of the explosive container. The container may be the casing of conventional munitions, the kettles, hoppers, and other metal containers used in the manufacture of explosives; the metal housing of rocket engines; and similar items. These fragments usually are small in size and travel initially at velocities of the order of thousands of feet per second.

C2.5.1.3. Secondary fragments are formed as a result of high blast pressures on structural components and items in close proximity to the explosion. These fragments are somewhat larger in size than primary fragments and travel initially at velocities in the order of hundreds of feet per second.

C2.5.1.4. A hazardous fragment is one having an impact energy of 58 ft-lb (79 joules) or greater.

(Changed by correspondence July 5, 2000)

C2.5.2 ***Fragment Distances***

C2.5.2.1 *Primary fragment distance minima are to protect personnel in the open; firebrand distance minima are to protect facilities. The larger of those two distances will be applied to:*

C2.5.2.1.1. Installation boundaries, unless manifestly inapplicable (unsuitable terrain, government land not open to the public, and so forth). For locations where installation boundary lines are penetrated by inhabited building Q-D arcs, the Service shall certify that conditions do not exist for the application of inhabited building protection to the encumbered area and shall establish procedures to monitor the area for any change in that status.

C2.5.2.1.2. Administration and housing areas.

C2.5.2.1.3. Athletic and other recreation areas except as described below.

C2.5.2.1.4. Flight-line passenger service functions.

C2.5.2.1.5. Main powerhouses providing vital utilities to a major portion of the installation.

C2.5.2.1.6. Storehouses and shops that by reason of their vital, strategic nature, or the high intrinsic value of their contents, should not be placed at risk.

C2.5.2.1.7. Functions that, if momentarily put out of action, will cause an immediate secondary hazard by reason of their failure to function.

C2.5.2.1.8. Private vehicles parked in administrative areas.

C2.5.2.2. Examples when minimum fragment and firebrand distances need not be applied are:

C2.5.2.2.1. Recreation or training facilities if these facilities are for the exclusive use of personnel assigned to the PES.

C2.5.2.2.2. Related and support DoD-controlled functions for which intermagazine and intraline distances are the usual protection levels.

C2.5.2.2.3. Maintenance, supply, and training facilities, and operations offices for the service of the logistics and operations functions of combat aircraft, Army battalion-size or smaller delivery or ammunition supply units, separate air defense firing batteries, or a single pier or wharf for which the ammunition in the PES is intended.

C2.5.2.2.4. Between PES and relatively static inert storage areas,

including parking areas for dead storage of military aircraft or vehicles.

C2.5.2.2.5. Between facilities in an operating line; between operating lines; and between operating lines and storage locations that normally are separated by inhabited building distances to protect workers and insure against interruption of production.

(*Changed by correspondence July 5, 2000)*

C2.5.2.3. The minimum distance for protection from hazardous fragments shall be based on primary and secondary fragments from the PES and the population and/or traffic density of the ES. It is defined as the distance at which the density of hazardous fragments becomes 1 per 600 ft^2. NOTE: This distance is not the maximum fragment range. Secondary fragments include debris such as that from structural elements of the facility and from non-confining process equipment likely to rupture into enough pieces to significantly contribute to the total number of expected fragments. Primary fragments include items such as those discussed in paragraph C2.5.1.2., above, and those from items listed in Table C9.T2. DDESB approved analyses and/or approved tests may be used to determine minimal distances for both primary and secondary fragments. DDESB Technical Paper No. 13 (reference (b)) is an example of a method to determine minimal distances for building debris, while references (an) and (ao) provide similar information for primary fragments. In the absence of appropriate analyses and/or tests, default hazardous debris distances defined below apply.

C2.5.2.3.1. For populous locations, i.e., those areas and/or functions identified in subsection C2.4.6., above, where military, civilian employees, dependent and/or public personnel are located, the minimum distance shall be that distance at which fragments, including debris from structural elements of the facility or process equipment, shall not exceed a hazardous fragment density of one hazardous fragment per 600 ft^2 (56 m^2). If this distance is not known, the following shall apply:

(Approved by 322nd Board Meeting)

C2.5.2.3.1.1. For all types of Hazard Division 1.1 in quantities $\leq$ 450 lbs NEW, the hazardous fragment distance (HFD), which equates to IBD, will be determined as follows:

C2.5.2.3.1.1.1. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, use "Earth-Covered Magazine" distances shown in C9.T1, as discussed in C9.3.1.1. Intraline criteria will be in accordance with C9.3.1.2.

C2.5.2.3.1.1.2. For Hazard Division 1.1 in an Undefined ECM, where the loading density [NEW (lbs)/internal magazine volume (ft^3)] is $\leq$ 0.028 lbs/ft^3, use "Earth-Covered Magazine" distances shown in C9.T1, as discussed in C9.3.1.1. Intraline criteria will be in accordance with C9.3.1.2.

C2.5.2.3.1.1.3. For Hazard Division 1.1 in an Undefined ECM where the loading density is > 0.028 lbs/ft^3, use "Earth-Covered Magazine - side and rear" distances of C9.T1 and for front exposure, apply the greater of "Earth-Covered Magazine -

front" IBD distance of C9.T1 or the HFD from C2.T1, for the NEW in the ECM. PTR is 60 percent of IBD or HFD, as applicable. Intraline criteria will be in accordance with C9.3.1.2.

C2.5.2.3.1.1.4. Where ECM, regardless of structural designation, have been designed, analyzed, or tested to have a reduced IBD and have been approved by the DDESB, use the approved IBD. PTR is 60 percent of IBD. Intraline criteria will be in accordance with C9.3.1.2.

C2.5.2.3.1.1.5. For Hazard Division 1.1 in a structure (excluding ECM) capable of stopping primary fragments, but which can contribute to the debris hazard, use hazardous debris and PTR distances found in C9.T6B. Intraline criteria will be in accordance with C9.3.1.2. Structures that are capable of stopping primary fragments include all heavy wall (H) and heavy wall/roof (H/R) aboveground sites (AGS), as defined in the Legend for C9.T8. Doors and other openings through which primary fragments could exit must be capable of stopping primary fragments from exiting the facility or will be barricaded in accordance with C5.3 to trap primary fragments that could exit the facility.

C2.5.2.3.1.1.6. For Hazard Division 1.1 in the open or in a structure incapable of stopping primary fragments, use HFD listed in C2.T1. Intraline criteria will be in accordance with C9.3.1.2. Structures (other than ECM) that are capable of stopping primary fragments include all heavy wall (H) and heavy wall/roof (H/R) aboveground sites (AGS), as defined in Legend for C9.T8. All other structures (other than ECM) are considered incapable of stopping primary fragments. PTR is 60 percent of HFD.

C2.5.2.3.1.1.7. Selected items have been evaluated for minimum HFD with results shown in C9.T2. Other items, through testing, have been hazard classified with a specific HFD presented in the format HD (xx)1.1. The HFD for these items is specified in hundreds of feet (in parenthesis), and they may not be listed in C9.T2. The distances for these two categories of select items apply only to items in the open.. When in facilities, secondary debris as well as primary fragments must be considered. If in a facility that can contain primary fragments, apply criteria of C2.5.2.3.1.1.1 through C2.5.2.3.1.1.5 above. If in a facility that cannot stop primary fragments, use the greater distance from C9.T2 (for the item being considered) or the HFD associated with the (xx)1.1 item or from C2.T1 for determining the applicable HFD. PTR is 60 percent of HFD. Intraline criteria will be in accordance with C9.3.1.2.

C2.5.2.3.1.1.8. For bare explosives in the open, distance is computed by the formula $d=40W^{1/3}$.

C2.5.2.3.1.2. For Hazard Division 1.1 NEWs in the range 451 to 30,000 lbs, HFD will be determined according to the below criteria. Public traffic route distance is 60 percent of the HFD, and intraline criteria, as applicable, will be in accordance with C9.3.1.2 or C9.3.1.3.

C2.5.2.3.1.2.1. The minimum HFD will be 1250 ft, as shown in C9.T1. Lesser distances are permitted if supported by a structural analysis. Facilities

sited at 1,235 ft or 1,245 ft per past standards will be considered to be in compliance with the 1,250 ft minimum requirement.

C2.5.2.3.1.2.2. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, use "Earth-Covered Magazine" distances shown in C9.T1, as discussed in C9.3.1.1.

C2.5.2.3.1.2.3. For Hazard Division 1.1 in an Undefined ECM, where the loading density is $\leq$ 0.028 lbs/ft^3, use "Earth-Covered Magazine" distances shown in C9.T1, as discussed in C9.3.1.1.

C2.5.2.3.1.2.4. For Hazard Division 1.1 in an Undefined ECM with minimum internal dimensions of 26 feet wide by 60 feet long, use "Earth-Covered Magazine - side and rear" distances of C9.T1 and "Other PES" distance of C9.T1 for the front exposure.

C2.5.2.3.1.2.5. For Hazard Division 1.1 in an Undefined ECM where the loading density is > 0.028 lbs/ft^3 and internal dimensions are less than 26 feet wide by 60 feet long, use "Other PES" distances of C9.T1 for front, side, and rear exposures.

C2.5.2.3.1.2.6. Selected items have been evaluated for minimum HFD with results shown in C9.T2. Other items, through testing, have been hazard classified with a specific HFD presented in the format HD (xx)1.1. The HFD for these items is specified in hundreds of feet (in parenthesis), and they may not be listed in C9.T2. The distances for these two categories of select items apply only to items in the open. PTR is 60 percent of HFD. When these items are placed in a facility, apply the criteria of C2.5.2.3.1.2.1 through C2.5.2.3.1.2.5 above, as appropriate.

C2.5.2.3.1.2.7. For bare explosives in the open, distance is computed by the formula $d=40W^{1/3}$.

C2.5.2.3.1.3. For Hazard Division 1.1 NEWs > 30,000 lbs, HFD will be in accordance with C9.T1. Lesser distances are permitted if supported by a structural analysis. PTR is 60 percent of HFD and intraline criteria, as applicable, will be in accordance with C9.3.1.2 or C9.3.1.3. The following apply to use of the reduced "Earth-Covered Magazine" distances shown in C9.T1, for the NEW range between 30,000 lbs and 250,000 lbs:

C2.5.2.3.1.3.1. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, where internal dimensions are a minimum of 26 feet wide by 60 feet long, use "Earth-Covered Magazine" distances shown in C9.T1.

C2.5.2.3.1.3.2. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, where internal dimensions are less than 26 feet wide by 60 feet long, use "Other PES" distances of C9.T1 for front, side, and rear exposures.

C2.5.2.3.1.3.3. For Hazard Division 1.1 in an Undefined

ECM, where internal dimensions are a minimum of 26 feet wide by 60 feet long, use "Earth-Covered Magazine - side and rear" distances of C9.T1 and "Other PES" distance of C9.T1 for the front exposure.

C2.5.2.3.1.3.4. For Hazard Division 1.1 in an Undefined ECM, where internal dimensions are less than 26 feet wide by 60 feet long, use "Other PES" distances of C9.T1 for front, side, and rear exposures.

Table C2.T1. Hazard Division 1.1 Hazardous Fragment Distances

NEW (pounds)	*HAZARDOUS FRAGMENT DISTANCE (Feet)*	*NEW (pounds)*	*HAZARDOUS FRAGMENT DISTANCE (Feet)*
<0.5	*236*	*80*	*638*
1	*291*	*85*	*643*
2	*346*	*90*	*648*
4	*401*	*95*	*652*
6	*433*	*100*	*658*
8	*456*	*125*	*744*
10	*474*	*150*	*815*
15	*506*	*175*	*875*
20	*529*	*200*	*927*
25	*546*	*225*	*973*
30	*561*	*250*	*1014*
35	*573*	*275*	*1051*
40	*583*	*300*	*1085*
45	*593*	*325*	*1116*
50	*601*	*350*	*1145*
55	*609*	*375*	*1172*
60	*616*	*400*	*1197*
65	*622*	*425*	*1220*
70	*628*	*450*	*1243*
75	*633*	*>450*	*1250*

NOTES (See C2.5.2.3.1.1 regarding applications of Table C2.T1)

1. *NEW < 100 Pounds: Hazardous Fragment Distance = 291.3 + [79.2 x ln(NEW)];*
   NEW $\geq$ 100 Pounds: Hazardous Fragment Distance = -1133.9 + [389 x ln(NEW)];
   NEW in pounds, Hazardous Fragment Distance in feet, with a minimum distance of 236 feet; ln is natural logarithm.

2. *NEW = exp [(Hazardous Fragment Distance/79.2) - 3.678]; Hazardous Fragment Distance < 658 feet;*
   NEW = exp [(Hazardous Fragment Distance/389) + 2.914]; 658 feet $\leq$ Hazardous Fragment Distance < 1250 feet;
   NEW in pounds, Hazardous Fragment Distance in feet; exp [x] is e^x.

3. *Use of equations given in Notes (1) and (2) to determine other Hazardous Fragment Distance-NEW combinations is allowed.*

4. *Public traffic route distance is 60 percent of Hazardous Fragment Distance.*

(Paragraph C2.5.2.3.1.2. was deleted by correspondence July 5, 2000)

C2.5.2.3.2. For sparsely populated locations, i.e., those populous locations where the personnel exposure is no greater than addressed in subparagraph C2.5.2.3.2.1. below, the minimum 1,250 ft (380 m) fragment distance may be reduced to 900 ft (270 m) if certain specific conditions exist as follows:

C2.5.2.3.2.1. No more than 25 persons are located in any sector bounded by the sides of a 45-degree angle, with the vertex at the PES, and the 900 ft (270 m) and 1,250 ft (380 m) arcs from the PES.

C2.5.2.3.2.2. The NEW of the PES does not exceed 11,400 lbs (5,170 kg).

C2.5.2.3.3. For public traffic routes, the minimum fragment and debris distance for Hazard Division 1.1 ammunition and explosives shall be based on the traffic density considered at three levels: high traffic density, medium traffic density, and low traffic density. The traffic density shall be averaged over a normal (non-holiday) week in terms of number of passengers during a 24-hour period. Minimum fragment distance reductions based on sparse population considerations addressed in subparagraph C2.5.2.3.2., above, do not apply to public traffic routes.

> Note: In applying criteria other than the default values given in subparagraphs C2.5.2.3.3.1., C2.5.2.3.3.2. and C2.5.2.3.3.3., below (which are based on car (and rail) speed of 50 mile/hour (80 km/hour), and a ship speed of 10 mile/hour (16 km/hour)), considerations such as the following shall be taken into account to establish acceptable exposure: speed of vehicles, number of passengers per vehicle, protection afforded by the vehicle, variation in daily traffic levels in relation to explosives activities, and seasonal traffic trends. The default value of two passengers per car may be used to estimate traffic density.

C2.5.2.3.3.1. **High Traffic Density.** If routes have 10,000 or more car and/or rail passengers per day, or 2,000 or more ship passengers per day, then inhabited building distance criteria apply (subparagraph C2.5.2.3.1., above).

C2.5.2.3.3.2. **Medium Traffic Density.** If routes have 400 or more, but less than 10,000 car and/or rail passengers per day, or 80 or more, but less than 2,000 ship passengers per day, then 60% of the specified minimum fragment distance for inhabited building distance applies. Medium traffic density criteria for minimum fragment distance apply, as a minimum, to recreational activity that is extensive and occurs on a regular basis.

C2.5.2.3.3.3. **Low Traffic Density.** If routes have less than 400 cars and/or rail passengers per day, or less than 80 ship passengers per day, then no minimum fragment distance is required. Minimum distance shall be based on blast criteria (K24/K30) only (subsection C2.4.4., above).

C2.5.2.3.4. For other exposures that are permitted at public traffic

route separation distances (subsections C2.4.3., C2.4.4. and C2.4.5., above), fragment and debris distance minima for Hazard Division 1.1 ammunition and explosives shall be at least 60% of the specified minimum fragment distance for inhabited building distance.

C2.6. THERMAL HAZARD

C2.6.1. **General.** The energetic materials used by Department of Defense all produce an exothermic reaction defined either as a deflagration or a detonation. A deflagration is an exothermic reaction that propagates from the burning gases to the unreacted material by conduction, convection, and radiation. In this process, the combustion zone progresses through the material at a rate that is less than the velocity of sound in the unreacted material. In contrast, a detonation is an exothermic reaction that is characterized by the presence of a shock wave in the material that establishes and maintains the reaction. A distinctive difference is that the reaction zone propagates at a rate greater than sound velocity in the unreacted material. Every material capable of detonating has a characteristic velocity that is under fixed conditions of composition, temperature, and density.

C2.6.2. **Permissible Exposures.** Personnel shall be provided protection that will limit thermal fluxes to 0.3 calories per square centimeter per second (12.56 kilowatts per square meter) when hazard assessments indicate the probability of accidental explosions is above an acceptable risk level as determined on a case-by-case basis by the DoD Component concerned.

C2.7. GROUND SHOCK

C2.7.1. **General.** Ground shock from explosions in underground facilities may endanger assets in neighboring chambers and produce damage to buildings on the surface. Protection of assets can be achieved by proper chamber separation distance and design. Distance requirements to protect surface structures are dependent upon site-specific geological conditions, as well as NEW and chamber loading density. Chapter 9 details quantity distance requirements for ground shock protection from explosions in underground facilities.

C2.7.2. **Permissible Exposures.** Procedures for predicting ground shock and calculating Q-D to protect facilities are in Chapter 9.

C2.8. CHEMICAL AGENT HAZARDS

These items are in Chapter 11.

C3. CHAPTER 3 HAZARD CLASSIFICATION AND COMPATIBILITY GROUPS

C3.1. CLASSIFICATION SYSTEM

C3.1.1. To ease identification of hazard characteristics and thus promote safe storage and transport of ammunition and explosives, the Department of Defense shall use the international system of classification devised by the United Nations Organization (UNO) for transport of dangerous goods. Ammunition and explosives also will be assigned the appropriate Department of Transportation (DOT) class and marking in accordance with 49 CFR 173 (reference (c)).

C3.1.2. The UNO classification system consists of nine hazard classes, two of which are applicable to ammunition and explosives as defined in this Standard, Classes 1 and 6, (See ST/SG/AC.10/1/Rev. 10 (reference (d))). Thirteen compatibility groups are included for segregating ammunition and explosives on the basis of similarity of characteristics, properties, and accident effects potential.

C3.1.3. Class 1 is divided into divisions that indicate the character and predominance of associated hazards:

C3.1.3.1. Mass-detonating (Division 1).

C3.1.3.2. Non-mass detonating fragment producing (Division 2).

C3.1.3.3. Mass fire (Division 3).

C3.1.3.4. Moderate fire-no blast (Division 4).

C3.1.3.5. Very insensitive explosives (Division 5).

C3.1.3.6. Extremely insensitive ammunition (Division 6).

(Changed as per 316th Board Meeting)

C3.1.4. This Standard uses the term “Hazard Division” instead of “Division”, both to emphasize the correspondence with the previous term “Hazard Class” and to avoid the cumbersome alternatives “Division 1 of Class 1,” and so forth. For further refinement of this hazard identification system, a numerical figure (in parenthesis) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands when distance alone is relied on for such protection. This number is placed to the left of the Hazard Division designators 1.1 through 1.3, such as (18)1.1, (08)1.2.*3*, and (02)1.3. C3.1.5. Articles that contain riot control substance without explosives components are classified as Class 6, Division 1, in the UNO Recommendations for Transport of Dangerous Goods. For DoD purposes, these articles are considered as Hazard Division 1.4 and may be stored in limit quantities with other base defense munitions. Bulk agent is also Hazard Division 6.1 in the UNO recommendations.

C3.2. **STORAGE PRINCIPLES**

C3.2.1. The highest degree of safety in ammunition and explosives storage could be assured if each item or division were stored separately. However, such ideal storage generally is not feasible. A proper balance of safety and other factors frequently requires mixing of several types of ammunition and explosives in storage.

C3.2.2. Ammunition and explosives may not be stored together with dissimilar materials or items that present positive hazards to the munitions. Examples are mixed storage of ammunition and explosives with flammable or combustible materials, acids, or corrosives.

C3.2.3. Different types, by item and division, of ammunition and explosives may be mixed in storage provided they are compatible. Ammunition and explosives are assigned to a compatibility group (CG) when they can be stored together without increasing significantly either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Considerations that were used in developing the CGs included but were not limited to:

C3.2.3.1. Chemical and physical properties.

C3.2.3.2. Design characteristics.

C3.2.3.3. Inner and outer packing configurations.

C3.2.3.4. Quantity-distance (Q-D) division.

C3.2.3.5. Net explosive weight (NEW).

C3.2.3.6. Rate of deterioration.

C3.2.3.7. Sensitivity to initiation.

C3.2.3.8. Effects of deflagration, explosion, or detonation.

C3.2.4. Subject to application of these standards and particularly to compatibility as defined herein, ammunition and explosives shall be mixed in storage when such mixing will facilitate safe operations and promote overall storage efficiency. Assignment of items to CGs requiring separate storage shall be minimized consistent with actual hazards presented and not based on administrative considerations or end use.

C3.2.5. As used in this Standard, the phrase “with its own means of initiation” indicates that the ammunition has its normal initiating device assembled to it and this device is considered to present a significant risk during storage. However, the phrase does not apply when the initiating device is packaged in a manner that eliminates the risk of causing detonation of the ammunition in the event of accidental functioning of the initiating device, or when fuzed end items are so configured and packaged as to prevent arming of the fuzed end items. The initiating

device may even be assembled to the ammunition provided its safety features preclude initiation of detonation of the explosives filler of the end item in the event of an accidental functioning of the initiating device.

C3.3. COMPATIBLE AMMUNITION AND EXPLOSIVES

C3.3.1. Different kinds of explosives may be stored together. However, items in one of the three groups listed below are not necessarily compatible with items in another of the groups:

C3.3.1.1. The various kinds of initiating explosives are compatible one with another.

C3.3.1.2. The various kinds of propellants are compatible one with another regardless of Q-D division.

C3.3.1.3. The various kinds of high explosives (HEs) are compatible one with another.

C3.3.2. Different types of ammunition within any one of the following seven groups are compatible and may be stored together:

C3.3.2.1. All types of initiating devices.

C3.3.2.2. All types of HE ammunition without their own means of initiation and without a propelling charge.

C3.3.2.3. All types of HE ammunition without their own means of initiation and with a propelling charge.

C3.3.2.4. All types of HE ammunition with their own means of initiation, with or without propelling charge.

C3.3.2.5. All pyrotechnics and all types of ammunition containing both explosives and illuminating, incendiary, smoke, or tear-producing agents except:

C3.3.2.5.1. Water activated pyrotechnics and ammunition.

C3.3.2.5.2. Ammunition containing white phosphorus (WP), flammable liquids, or gas.

C3.3.2.6. All types of ammunition containing both explosives and WP.

C3.3.2.7. All types of ammunition containing both explosives and flammable liquids or gels.

C3.3.3. Ammunition items in one of the groups in subsection C3.3.2., above, generally are not compatible with items in other groups.

C3.3.4. Bulk propellants and explosives may be stored with ammunition containing like materials:

C3.3.4.1. Bulk propellants are compatible with propelling charges without projectiles, and cartridges with solid or inert projectiles.

C3.3.4.2. Bulk HE are compatible with HE ammunition without its own means of initiation and without a propelling charge.

C3.3.5. Ammunition and explosives in substandard or damaged packaging, in a suspect condition, or with characteristics that increase the risk in storage, are not compatible with other ammunition and explosives and shall be stored separately.

C3.4. STORAGE AND COMPATIBILITY GROUPS (CGs)

In view of ammunition and explosives storage principles and the considerations for mixed storage, ammunition and explosives are assigned to the appropriate one of 13 CGs (A through H, J, K, L, N, and S).

C3.4.1. **Group A**. Initiating explosives. Bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, dry cyclonite (RDX), and dry pentaerythritol tetranitrate (PETN).

C3.4.2. **Group B**. Detonators and similar initiating devices not containing two or more independent safety features. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and fuzes.

C3.4.3. **Group C**. Bulk propellants, propelling charges, and devices containing propellant with or without their means of ignition. Items that upon initiation will deflagrate, explode, or detonate. Examples are single-, double-, triple-base, and composite propellants, rocket motors (solid propellant), and ammunition with inert projectiles.

C3.4.4. **Group D**. Black powder, HE, and ammunition containing HE without its own means of initiation and without propelling charge, or a device containing an initiating explosive and containing two or more independent safety features. Ammunition and explosives that can be expected to explode or detonate when any given item or component thereof is initiated except for devices containing initiating explosives with independent safety features. Examples are bulk trinitrotoluene (TNT), Composition B, black powder, wet RDX or PETN, bombs, projectiles, cluster bomb units (CBUs), depth charges, and torpedo warheads.

C3.4.5. **Group E**. Ammunition containing HE without its own means of initiation and containing or with propelling charge (other than one containing a flammable or hypergolic liquid). Examples are artillery ammunition, rockets, or guided missiles.

C3.4.6. **Group F**. Ammunition containing HE with its own means of initiation and with propelling charge (other than one containing a flammable or hypergolic liquid) or without a propelling charge.

C3.4.7. **Group G**. Fireworks, illuminating, incendiary, and smoke, including hexachlorethane (HC) or tear producing munitions other than those munitions that are water activated or which contain WP or flammable liquid or gel. Ammunition that, upon functioning, results in an incendiary, illumination, lachrymatory, smoke, or sound effect. Examples are flares, signals, incendiary or illuminating ammunition, and other smoke or tear producing devices.

C3.4.8. **Group H**. Ammunition containing both explosives and WP or other pyrophoric material. Ammunition in this group contains fillers which are spontaneously flammable when exposed to the atmosphere. Examples are WP, plasticized white phosphorus (PWP), or other ammunition containing pyrophoric material.

C3.4.9. **Group J**. Ammunition containing both explosives and flammable liquids or gels. Ammunition in this group contains flammable liquids or gels other than those which are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid- or gel-filled incendiary ammunition, fuel-air explosive (FAE) devices, flammable liquid-fueled missiles, and torpedoes.

C3.4.10. **Group K**. Ammunition containing both explosives and toxic chemical agents. Ammunition in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation. Examples are artillery or mortar ammunition (fuzed or unfuzed), grenades, and rockets or bombs filled with a lethal or incapacitating chemical agent (see note 4, Table C3.T1).

C3.4.11. **Group L**. Ammunition not included in other compatibility groups. Ammunition having characteristics that do not permit storage with other types of ammunition, or kinds of explosives, or dissimilar ammunition of this group. Examples are water-activated devices, prepackaged hypergolic liquid-fueled rocket engines, certain FAE devices, triethyl aluminum (TEA), and damaged or suspect ammunition of any group. Types presenting similar hazards may be stored together but not mixed with other groups.

C3.4.12. **Group N**. Hazard Division 1.6 ammunition containing only extremely insensitive detonating substance (EIDS). Examples are bombs and warheads. If dissimilar Group N munitions, such as Mk 82 and Mk 84 Bombs, are mixed together and have not been tested to assure non-propagation; the mixed munitions are considered to be Hazard Division 1.2, Compatibility Group D for purposes of transportation and storage.

C3.4.13. **Group S**. Ammunition presenting no significant hazard. Ammunition so packaged or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not hinder firefighting significantly. Examples are thermal batteries, explosive switches or valves, and other ammunition items packaged to meet the criteria of this group.

C3.5. MIXED STORAGE

C3.5.1. Except as noted in subsection C3.5.2. below, ammunition and explosives of different compatibility groups may only be mixed in storage as indicated in Table C3.T1.

C3.5.2. Certain continental United States (CONUS) locations that are designated by a DoD Component, and site approved by the DDESB, to store ammunition and explosives packaged in configurations for rapid response; e.g., Rapid Deployment Force, are authorized to mix compatibility groups as required to achieve the optimum load needed by the receiving troops. The maximum credible event at any of these storage sites shall be limited to 8820 lbs NEW (4000 kg NEQ). For the determination of the NEW at above grade storage sites, the following explosives shall be excluded:

C3.5.2.1. Propelling charges in Hazard Division 1.2 fixed, semifixed, mortar, and rocket ammunition.

C3.5.2.2. The quantity of explosives in Hazard Division 1.3 items, unless the site contains only Hazard Division 1.3, in which case Hazard Division 1.3 Q-D apply. In the application of this paragraph to separate loading ammunition, an equal number of propelling charges may be stored with the separate loading projectiles.

C3.5.3. The Q-D requirements in Chapter 9 shall be applied to the storage locations addressed in subsection C3.5.2., above.

Table C3.T1. StorageCompatibilityMixingChart

Groups	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z					X	X
C		Z	X	X	X	Z	Z					X	X
D		Z	X	X	X	Z	Z					X	X
E		Z	X	X	X	Z	Z					X	X
F		Z	Z	Z	Z	X	Z					Z	X
G		Z	Z	Z	Z	Z	X					Z	X
H								X					X
J									X				X
K										Z			
L													
N		X	X	X	X	Z	Z					X	X
S		X	X	X	X	X	X	X	X			X	X

Notes:

1. The marking "X" at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted according to Note 2, below.

2. The marking "Z" at an intersection of the above chart indicates that when warranted by operational considerations or magazine nonavailability, and when safety is not sacrificed, logical mixed storage of limited quantities of some items of different groups may be approved. These relaxations involving mixed storage shall be approved by the DoD Component and are not considered waivers. Combinations that violate the principles of subsection C3.2.3., above, require justification by a waiver or exemption. Items from Group B or Group F shall be segregated from articles of other compatibility groups by means that prevent propagation of fire or detonation. Examples of acceptable combinations are:

    a. Hazard Division 1.1, Group A, initiating explosives with Hazard Division 1.1, Group B, fuzes not containing two or more independent safety features.

    b. Hazard Division 1.3, Group C, bulk propellants or bagged propelling charges with Hazard Division 1.3, Group G, pyrotechnics, without their own means of initiation.

3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled round, that is, WP filler in Group H, HE filler in Groups D, E, or F, as appropriate.

4. Group K requires not only separate storage from other groups, but also may require separate storage within the group. The controlling DoD Component shall determine which items under Group K may be stored together and those which must be stored separately.

5. Ammunition items without explosives that contain substances properly belonging to another U.N. hazard class may be assigned to the same compatibility group as items containing explosives and the same substance, and be stored with them.

6. DoD Components may authorize ammunition designated "Practice" by National Stock Number (NSN) and nomenclature to be stored with the fully loaded ammunition it simulates.

7. DoD Components may authorize the mixing of compatibility groups, except items in Groups A, K and L in limited quantities (generally 1000 lbs or less).

8. For purposes of mixing, all items must be packaged in approved storage/shipping containers. Items shall not be opened for purposes of issuing unpackaged munitions in storage locations. Outer containers may be opened in storage locations for purposes of inventorying; for removing munitions still inside an approved inner package in limited amounts; and for magazines storing only Hazard Division 1.4 items, unpacking inspecting, and repacking the Hazard Division 1.4 ammunition.

9. When using the "Z" mixing authorized by Note 2, articles of either compatibility Group B or F, each shall be segregated in storage from articles of other compatibility groups by means that prevent the propagation of Group B or F articles to articles of other compatibility groups.

10. If dissimilar Hazard Division 1.6, Group N munitions, such as Mk 82 and Mk 84 Bombs, are mixed together and have not been tested to assure non-propagation; the mixed munitions are considered to be Hazard Division 1.2, Compatibility Group D for purposes of transportation and storage. When mixing Group N munitions with Groups B through G, see Chapter 9, paragraphs C9.2.1.8. through C9.2.1.10. about changing Q-D hazard divisions.

C3.6. **UNDERGROUND STORAGE**

Ammunition with smoke producing, incendiary, flammable liquid or toxic chemical agent fillers may be stored in single chamber underground facilities, but shall not be stored in multi-chamber facilities. Other than this restriction, ammunition and explosives of all compatibility groups may be placed in underground storage in compatible combinations as permitted above.

C3.7. EXPLOSIVES HAZARD CLASSIFICATION PROCEDURES

DoD Explosives Hazard Classification Procedures (DLAR 8220.1, TB 700-2, NAVSEAINST 8020.8B, and TO 11A-1-47, reference (e)) shall be used as a basis for assignment of hazard divisions to all ammunition and explosives except those that are candidates for designation as extremely insensitive detonating substances (EIDS) and EIDS ammunition. EIDS and EIDS ammunition shall be assigned to hazard divisions as indicated in section C3.12., below.

C3.8. EIDS AND EIDS AMMUNITION

C3.8.1. EIDS comprises Hazard Division 1.5 type explosive substances that, although mass detonating, are so insensitive that there is negligible probability of initiation or transition from burning to detonation in storage.

C3.8.2. EIDS ammunition, Hazard Division 1.6, is ammunition that contains EIDS and that has demonstrated through test results (section C3.12., below) that the mass and confinement effects of the ammunition case are negligible on the probability of initiation or transition from burning to detonation of the EIDS in transport or storage. Such ammunition when intentionally initiated will be incapable of transferring detonation to another (that is, propagating).

C3.9. TEST PROCEDURES DOCUMENTS

ST/SG/AC.10/11/Rev. 2 (reference (f)) sets forth procedures to be used in the EIDS and EIDS ammunition (Hazard Division 1.6) testing required by sections C3.10. through C3.12., below.

C3.10. SCREENING TESTS FOR EIDS

Substances that are candidates for the designation as EIDS shall be subjected to the screening tests given by Test Series 3 in DLAR 8220.1, TB 700-2, NAVSEAINST 8020.8B, TO 11A-1-47 (reference (e)) and specified in Table C3.T2. Failure to achieve required results in a single test disqualifies the substance as a candidate EIDS.

Table C3.T2. Test Procedures

Test	Test Procedure Number	Required Results
Bureau of Explosives Machine Test	3(a)(i)	Pass drop height of 101.6 mm (4.0 in)
ABL Friction Test	3(b)(iii)	No reaction
Thermal Stability Test at 75°C	3(c)	No reaction
Small Scale Burning Test	3(d)(i)	No detonation or explosion

C3.11. REQUIRED TESTS FOR EIDS

Substances judged on the basis of screening test results stated in section C3.10, above, to be legitimate candidates for designation as EIDS shall be subjected to tests specified in Table C3.T3. Required results for all tests as stated shall be achieved for designation as EIDS.

Table C3.T3. EIDS Tests

Test	UN Test Number [1]	No. of Trials	Sample	Failure Criteria
EIDS Cap	7(a)	3	80 mm diameter 160 mm length	Detonation
EIDS Gap	7(b)	3	73 mm diameter 280 mm length	Detonation
Susan Impact	7(c)(i)	5	51 mm diameter 102 mm length	≥27kPa at 3.05 m for 333 m/s impact
EIDS Bullet Impact	7(d)(i)	6	45 mm diameter 200 mm length	Explosion or detonation
EIDS External Fire	7(e)	3	45 mm diameter 200 mm length 5 samples/test	Detonation and/or >15 m debris throw
EIDS Slow Cook-off	7(f)	3	45 mm diameter 200 mm length	Detonation and or >3 fragments

Note 1 Detailed test descriptions are provided in *Recommendations on the Transport of Dangerous Goods, Tests and Criteria* (reference (f)).

C3.12. REQUIRED TESTS FOR EIDS AMMUNITION (HAZARD DIVISION 1.6)

To be classified as EIDS ammunition, ammunition containing EIDS in storage and/or transport configuration must be subjected to tests specified in Table C3.T4 and achieve required results for all tests as stated. In addition, it must be demonstrated by actual test that intentional detonation of one item will be incapable of propagating detonation to another like item.

Table C3.T4. EIDS Ammunition (Hazard Division 1.6) Tests

Test	UN Test No[1]	No of Trials	Stimulus	Failure Criteria
1.6 Article External Fire	7(g)	1	3 or more articles in open wood or fuel fire	Hazard Division 1.1, 1.2 or 1.3 response
1.6 Article Slow Cook-off	7(h)	2	Gradually increasing thermal environment up to 365°C	No reaction more severe than burning[2]
1.6 Article Bullet Impact	7(j)	3	0.50 cal AP ammo fired at service velocity in 3-round burst	Detonation
1.6 Article Stack Test	7(k)[3]	3	Detonate all-up article in shipping or storage configuration containing 3 or more rounds	No propagation of detonation

Notes:

1. Detailed test descriptions are provided in *Recommendations on the Transport of Dangerous Goods, Tests and Criteria* (reference (f)).

2. The energetic material may ignite and burn and the case may melt or weaken sufficiently to allow mild release of combustion gases. Case closures may be thrown no more than 15 m.

3. U.S. implementation of the test requires confinement equivalent to the more severe conditions of storage or transport configuration for two tests. One test is conducted without confinement to allow collections of fragment and airblast data.

C3.13. HAZARD CLASSIFICATION AND COMPATIBILITY GROUPS

Table C3.T5. provides examples of the relationship between compatibility groups, Q-D divisions, and DOT classes for items classified in accordance with DLAR 8220.1, TB 700-2, NAVSEAINST 8020.8B, TO 11A-1-47 (reference (e)). Table C3.T6. assigns Q-D divisions and CGs to substances qualified as EIDS under the provisions of section C3.11., above, and ammunition qualified as EIDS ammunition under provisions of section C3.12., above.

C3.14. CLASSES 1 OR 6 CHEMICAL AGENT HAZARDS OR COMBINED CHEMICAL AGENT AND EXPLOSIVES HAZARDS

Items in these classes are chemical agent-filled ammunition, chemical agents, and chemical agent-filled components. Depending upon the type of agent, its persistency, toxicity, or other characteristics, the primary safety consideration may be the area of agent dispersal rather than blast or fragment distance that usually control in the case of other ammunition. Items that contain only toxic chemical components are assigned to Hazard Division 6.1. Items that contain both explosives and toxic chemical components are assigned to Hazard Divisions 1.1 through 1.4, as appropriate. Hazard Division 6.1 requirements shall also be applied so that the explosives and toxic chemical hazards both are considered.

Table C3.T5. HazardClassifications/Compatibility Groups

Items	CG	DoD Q-D Hazard Division	Old DoT Class (Note 1)
1. Initiating Explosives	A	1	A
2. Detonators and similar initiating devices	B	1, 2, or 4	A or C
3. Bulk propellants, propelling charges, and devices containing propellant with or without means of initiation	C	1, 2, 3, or 4	A, B, or C
4. EIDS, black powder, high explosives, and HE ammunition without its own means of initiation and without a propelling charge	D	1, 2, or 5	A
5. HE ammunition with its own means of initiation, with a propelling charge	E	1 or 2	A
6. HE ammunition with its own means of initiation with or without a propelling charge	F	1 or 2	A
7. Fireworks and illuminating, incendiary, smoke, or tear producing ammunition other than ammunition that is activated by exposure to water or the atmosphere	G	1, 2, 3, or 4	A, B, or C
8. Ammunition containing both explosives and white phosphorus or other pyrophoric material	H	2 or 3	A or B
9. Ammunition containing both explosives and flammable liquid or gel filler	J	3	B
10. Ammunition containing both explosives and toxic chemical agent	K	2	A
11. Ammunition not included in other groups, requiring separate storage	L	1, 2, 3, or 4	A, B, or C
12. Ammunition containing only EIDS	N	6	
13. Ammunition that presents no significant hazards	S	4 or none	C or exempt
Note 1 See 49 CFR 173 (reference (c)), current version.			

(Updated after the 316th Board Meeting)

Table C3.T6. EIDS and EIDS Ammunition Hazard Divisions

EIDS and EIDS Ammunition	Hazard Classification
EIDS bulk	1.5D
EIDS Loaded projectiles and/or warheads w/o fuzes or with EIDS fuzes[1, 2]	1.6N
EIDS fuzes[1]	1.4D, 1.4S, 1.6N
EIDS loaded projectiles and/or warheads w/1.3 propelling charges and without fuzes or with EIDS fuzes[1, 2]	1.2.*1*C,*1.2.2C*, 1.3C, 1.4C
EIDS loaded projectiles and/or warheads with non-EIDS fuzes and without 1.3 propelling charges	1.2.*3*D[3, 4], 1.4D[4]
EIDS loaded projectiles and/or warheads with non-EIDS[2,4] fuzes and with 1.3 propelling charges	1.2.*2.1*E[3, 4],*1.2.2E*[3,4] 1.4E[4]

Notes:

1. "EIDS Fuzed" means that the fuze has an EIDS booster with an out-of-line EIDS explosive and two or more independent safety features. The fuze must be certified as invulnerable to accidental detonation of the warhead.

2. Fuzed configuration must be tested for propagation. Fuzed Hazard Division 1.6 ammunition must contain either an EIDS fuze or a non-explosive fuze (fuze contains no explosive); otherwise the ammunition is classified as unit risk Hazard Division 1.2 *(HD 1.2.3)*.

3. Unit risk Hazard Division 1.2 may be justified on a case-by-case basis.

4. Fuze must have two or more independent safety features and independently classified Group D.

C4. CHAPTER 4 PERSONNEL PROTECTION

C4.1. SCOPE AND APPLICATION

This Chapter establishes blast, fragment, and thermal hazards protection principles and applies to all operations and operational facilities where personnel are exposed to ammunition and explosives hazards during industrial, processing, manufacturing, maintenance, renovation, demilitarization and similar operations. Structures to Resist the Effects of Accidental Explosions (TM 5-1300, NAVFAC P-397, AFM 88-22 (reference (g))) details design procedures to achieve personnel protection as required by this Chapter; protect facilities and equipment from damage by blast, fragments, and debris; and prevent propagation of explosions.

C4.2. HAZARD ASSESSMENT

C4.2.1. Assessment of risk shall be performed on all new or modified industrial operations and facilities involving ammunition and explosives. Based upon this assessment, engineering design criteria for the facility or operation shall be developed for use in the selection of appropriate equipment, shielding, engineering controls, and protective clothing for personnel. The assessment shall include such factors as:

C4.2.1.1. Initiation sensitivity.

C4.2.1.2. Quantity of materials.

C4.2.1.3. Heat output.

C4.2.1.4. Rate of burning.

C4.2.1.5. Potential ignition and initiation sources.

C4.2.1.6. Protection capabilities of shields, various types of clothing, and fire protection systems.

C4.2.1.7. Personnel exposure with special consideration.

C4.2.2. New or modified buildings sited within any explosives inhabited building Q-D arc that have glass panels and that contain personnel shall receive a glass breakage personnel hazard risk assessment.

C4.3. PERMISSIBLE EXPOSURES

C4.3.1. Accidental Ignition/Initiation of Explosives

C4.3.1.1. Personnel shall be provided protection from potential blast

overpressures, hazardous fragments, and thermal effects with attendant respiratory and circulatory hazards, when assessments performed in compliance with section C4.2., above, indicate the probability of an accidental explosion with attendant overpressures, and hazardous fragments, or an accidental flash fire with attendant thermal hazards is above an acceptable risk level as determined on a case-by-case basis by the DoD Component concerned.

C4.3.1.2. When required by paragraph C4.3.1.1., above, protection afforded all personnel must be capable of limiting incident blast overpressure to 2.3 psi, fragments to energies of less than 58 ft-lb, and thermal fluxes to 0.3 calories per square centimeter per second. Those protection levels shall be certified through analysis for cases where personnel are at distances less than K24 or for situations where personnel exposure criteria are obviously exceeded. Shields complying with MIL-STD-398 (reference (h)) are acceptable protection.

C4.3.2. **Intentional Ignition/Initiation of Explosives**. At operations where intentional ignition/initiation of explosives are conducted, such as function, proof, lot acceptance, testing, and so forth, and where shielding is required as determined on a case-by-case basis by the DoD Component concerned, protection afforded all personnel will meet the requirements of paragraph C4.3.1.2., above, and must also be capable of limiting overpressure levels in personnel-occupied areas to satisfy MIL-STD-1474C (reference (i)), containing all fragments, and limiting thermal flux to:

$$Q \text{ (calories/square centimeter/second)} = 0.62t^{-0.7423}$$

where t is the time in seconds that a person is exposed to the radiant heat. Shields complying with MIL-STD-398 (reference (h)) are acceptable protection.

C4.4. PROTECTIVE MEASURES

Personnel protection requirements of section C4.3., above, may be achieved in one or more of the following ways:

C4.4.1. Elimination or positive control of ignition and initiation stimuli.

C4.4.2. Sufficient distance or barricades to protect from blast or fragments.

C4.4.3. In those areas of facilities where exposed thermally energetic materials are handled that have a high probability of ignition and a large thermal output as indicated by hazard assessments performed in compliance with section C4.2., above, a fire detection and extinguishing system that is sufficiently quick-acting and of adequate capacity to extinguish potential flash fires in their incipient state will protect both personnel and property. Design and installation of the system must maximize speed of detection and application of the extinguishing agent.

C4.4.4. In ammunition operational areas where it is essential for personnel to be present, and the hazard assessment indicates that an in-process thermal hazard exists, use of thermal shielding between the thermal source and personnel is an acceptable means of protection. If shields are used, they shall comply with MIL-STD-398 (reference (h)). If shielding is not

possible, or if that provided is inadequate for protection of exposed personnel, including their respiratory and circulatory systems, augmentation with improved facility engineering design, personnel protective clothing and equipment may be necessary.

C4.4.5. Thermal protective clothing must be capable of limiting bodily injury to first degree burns (0.3 calories per square centimeter per second with personnel taking turning-evasive action) when the maximum quantity of combustible material used in the operation is ignited.

C4.4.6. Protective clothing selected must be capable of providing respiratory protection from the inhalation of hot vapors and toxicological effects when the hazard assessment indicates adverse effects would be encountered from the inhalation of combustion products.

C4.4.7. Personnel hazards from glass breakage can be minimized by means such as building orientation and/or keeping the number of exposed glass panels and panel size to a minimum. When window panels are necessary and risk assessment determines a glass hazard will be present, blast resistant windows must be used. The framing and/or sash of such panels must be of sufficient strength to retain the panel in the structure.

C5. CHAPTER 5 FACILITIES CONSTRUCTION AND SITING

C5.1. GENERAL

Construction features and location are important safety considerations in planning facilities that are to be a PES or exposed to the damaging effects of potential explosions; i.e., an ES. The effects of potential explosions may be altered significantly by construction features that limit the amount of explosives involved, attenuate resultant blast overpressure or thermal radiation, and reduce the quantity and range of hazardous fragments and debris. Proper location of exposed sites in relations to PESs ensures against unacceptable damage and injuries in the event of an incident. This Chapter contains siting and construction standards to be used within the Department of Defense.

C5.2. AMMUNITION AND EXPLOSIVES STORAGE FACILITIES

C5.2.1. **Earth-covered magazines (ECM).** The primary objective of an earth-covered magazine is to provide protection for its assets. To qualify for the default intermagazine distances in Table C9.T5., a magazine, acting as an ES, must not collapse. Substantial plastic deformation of the magazine may occur. However, deflections should be limited within the air gap around the stored assets so that the deformed structure or its doors(s) do not strike the contents. Due to their extreme sensitivities, special protective precautions must be taken for compatibility group (CG) B explosive materials.

(Changed by correspondence July 5, 2000)

C5.2.1.1. Table C9.T5 contains default intermagazine siting criteria for ECMs with headwall and blast door hardnesses of 7-Bar, 3-Bar, and Undefined. All ECMs in TableC9.T5 have the same earth cover requirements.

C5.2.1.1.1. Minimum design considerations for ECMs

C5.2.1.1.1.1. Consider conventional (live, dead, snow, etc.) loads for the barrel of an arch-shaped ECM.

C5.2.1.1.1.2. Consider conventional (live, dead, snow, etc.) and blast-induced loads for the roof of a flat-roofed ECM.

C5.2.1.1.1.3. Consider conventional (live, dead, snow, etc.) loads for the rear wall of an arch-shaped ECM and for the rear and sidewalls of a flat-roofed ECM.

C5.2.1.1.1.4. Consider blast-induced loads for the head wall and door of an ECM.

C5.2.1.1.2. Expected blast loads from an ECM

C5.2.1.1.2.1. The expected blast load on the head wall and door of

an ES ECM oriented side-on to the side of a PES at a 1.25 $W^{1/3}$ distance (feet) is a triangular pulse with peak overpressure of 45 psi (3-bars) and impulse of 11.3·$W^{1/3}$ psi-ms (1.0·$Q^{1/3}$ bar-ms).

C5.2.1.1.2.2. The expected blast load on the head wall and door of an ES ECM oriented head-on to the rear of a PES at a distance of 2·$W^{1/3}$ (feet) is a triangular pulse with peak overpressure of 100 psi (7-bars) and impulse of 13.9 $W^{1/3}$ psi-ms (1.23·$Q^{1/3}$ bar-ms).

C5.2.1.1.2.3. The expected blast load on the roof of a flat-roofed ES ECM oriented rear-on to the front of a PES at a distance of 2·$W^{1/3}$ (feet) is a triangular pulse with peak overpressure of 108 psi (7.5- bars) and impulse of 19·$W^{1/3}$ psi-ms (1.7·$Q^{1/3}$ bar-ms).

(Changes approved at 321st Board Meeting)

C5.2.1.2. ECM may be approved for storage of up to 500,000 Pounds NEW of Hazard Division 1.1 in accordance with C9.T5. DDESB Technical Paper No. 15, Approved Protective Construction (reference (ap)), provides lisings of the various types of ECM that have been constructed over the years. These magazines are identified by their structural strength designator (i.e. "7-Bar", 3'Bar", or Undefined"). Table 4-1 of Reference (ap) lists the "7-Bar" and "3-Bar" ECM designs that are currently approved for new construction.

C5.2.1.2.1. If an ECM's Drawing number(s) is not listed in reference (ap), it will be treated as an "Undfined" ECM, until a structural analysis is performed to show that the ECM qualifies for another strength designation, or support documentation is provided to show the ECM had been approved previously by the DDESB with a different strength designation.

C5.2.1.2.2. For existing, arch-shaped "Undefined" ECM, the Guide for Evaluating Blast Resistance of Non-Standard Magazines (reference (aq)) may be used to determine if an "Undefined" ECM could qualify as a "7-Bar" or a "3-Bar" ECM.

C5.2.1.2.3. DDESB approval is required prior to any change in an ECM's structural strength designator.

C5.2.1.2.4. Certain ECM, aboveground magazines, and containers have been approved with reduced NEW and/or reduced Q-D and these are also listed in Table 4-4 of reference (ap). Use of these structures/containers requires that their use and siting meet all conditions/restrictions specified in the design and approval documentation, as described in reference (ap).

C5.2.2. **Barricaded Open Storage Modules**

C5.2.2.1. As depicted in Figure C5.F1, a module is a barricaded area comprised

of a series of connected cells with hard surface storage pads separated from each other by barricades. A light metal shed or other lightweight fire retardant cover may be used for weather protection for individual cells. Heavy structures (reinforced concrete, dense masonry units) or flammable material will not be used.

C5.2.2.2. Module storage (open storage) is a temporary expedient and may be used as determined necessary by the DoD Component concerned. However, from the standpoint of explosives safety as well as reliability, priority shall be given to the use of ECM for items requiring protection from the elements or long-term storage.

C5.2.2.3. The maximum NEW permitted to be stored within each cell is 250,000 lbs (total of the explosives fill of all Hazard Division 1.1 or 1.2 ammunition).

C5.2.2.4. **Authorized Storage**

C5.2.2.4.1. The items that may be stored in modules are limited to HE bombs (fuzed or unfuzed, with or without fins), similarly cased Hazard Division 1.1 ammunition, and the following contained in nonflammable or metal shipping containers: 30 mm and smaller ammunition, CBUs, inert munitions components, and Hazard Division 1.4 munitions.

C5.2.2.4.2. Stocks in each module normally shall be limited to one type of item in the standard shipping configuration unless mixed storage is authorized by the DoD Component concerned.

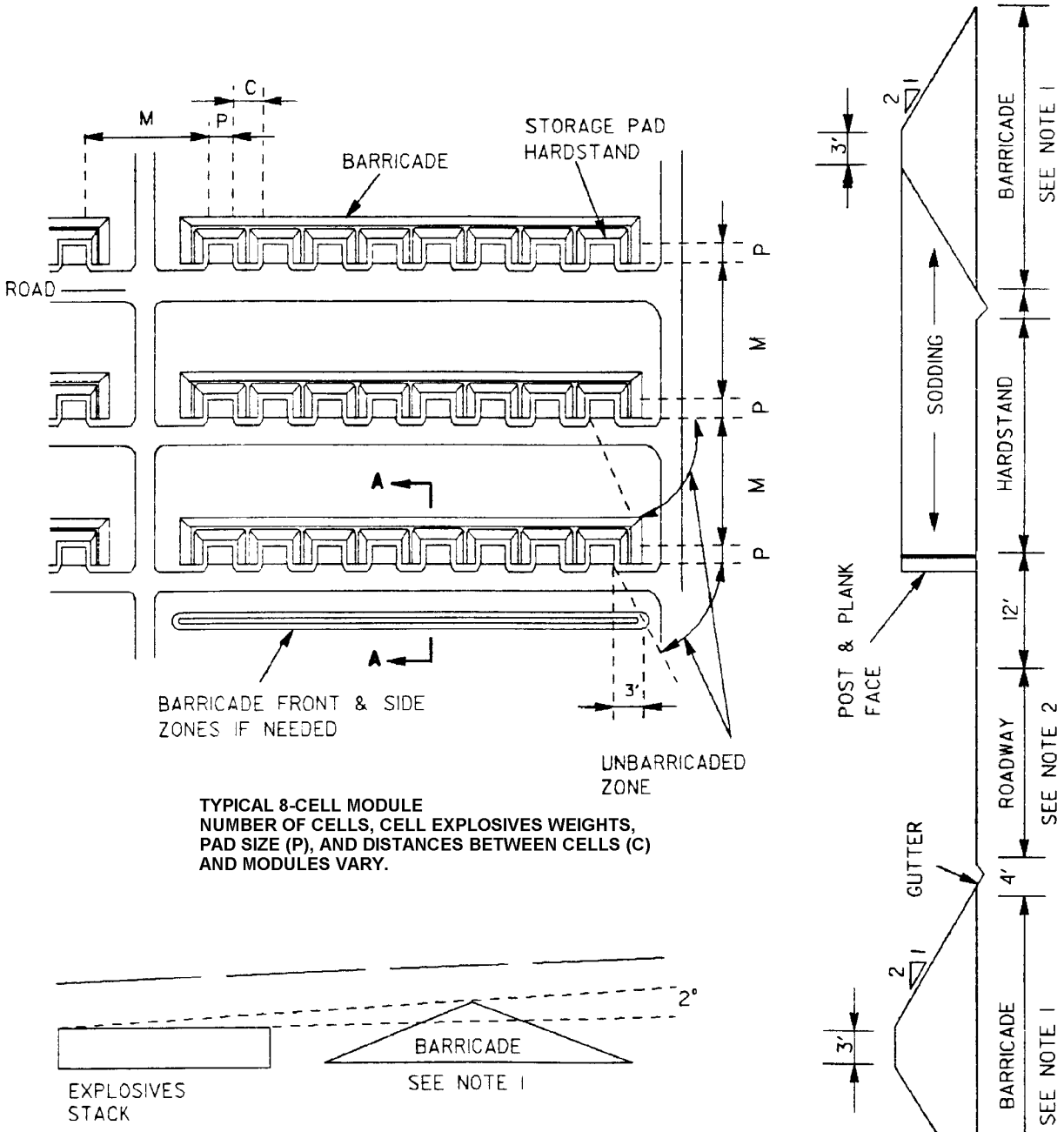
C5.2.2.4.3. Module storage of ammunition in flammable outer-pack configurations shall be minimized. Combustible dunnage or other flammable material shall not be stored in or within 100 feet of modules.

C5.2.2.4.4. When fire retardant tarpaulins are used to cover ammunition in modules, ventilation shall be provided between the tarpaulin and the stored ammunition.

C5.2.2.5. **Barricade Requirements**

C5.2.2.5.1. All barricades used in forming the module and its cells shall meet the requirements specified in section C5.3., below. Minimum barricade height required above the top of the stack is influenced by the width or length of the stack (storage pad size) and the distance between the stack and the top of the barricade. Heights in Table C5.T1. represent the minimum requirement for barricade locations based upon storage pad sizes and separations shown. When feasible, barricade heights shall be increased by using a 5^{o} angle above the horizontal instead of the 2^{o} shown in Figure C5.F1. Reference paragraph C5.3.3.1., below.

C5.2.2.5.2. The centerlines of barricades between cells of the module shall be located at a point halfway between adjacent munitions storage pads. Back and end (outside) barricades shall be located at the same distance from the pads as those between the cells.



NOTES:
1. REFER TO PARAGRAPH C5.3.2.1 FOR ALTERNATE BARRICADE TYPES.
2. TE BE DETERMINED BY THE INSTALLATION

Figure C5.F1. Typical Eight-cell Module

Table C5.T1. Intermagazine Separation for Barricaded Storage Module for Mass-Detonating Explosives

Net Pounds of Explosives	Minimum Explosives-to-Explosives Distance in Feet (Barricaded) Between Cells & Modules $D = 1.1W^{1/3}$	Barricaded Height Based Upon Storage Pad Size	
		Cell Storage Pad Size (Width or Depth) in ft.[1]	Minimum Height Above Top of Stack in ft.
Column 1	Column 2	Column 3	Column 4
50,000	40	30	2
100,000	50	30	2
125,000	55	30	2
150,000	60	30	2
175,000	60	30	2
200,000	65	30	2
200,000	65	40	2 ½
225,000	65	40	2 ½
250,000	70	40	2 ½
250,000	70	50	3

Note 1 The barricade height above the explosives stack shown in Column 4 will be increased 6 inches for each 10 ft increase in width or depth of the pad size shown in Column 3.

C5.2.2.5.3. Maximum advantage shall be taken of natural barriers existing in the topography in siting these modules. If natural barriers are used to substitute for a portion of the module barricade, the protection provided shall be at least equivalent to that of the barricade.

C5.2.2.6. Cell storage pad size may be as required to accommodate stocks. Table C5.T1. gives minimum pad sizes necessary to handle most items in the explosives quantities given. Storage pads shall be hard-surfaced, if possible, in order to lessen the effects of earth shock from an accidental explosion. No restrictions are imposed upon the arrangement of cells within a module or upon the arrangements of groups of modules, except that cell openings may not face toward each other unless they are barricaded or meet the standard Q-D criteria for unbarricaded aboveground magazines.

C5.2.2.7. **Siting Criteria**

C5.2.2.7.1. **Separation Between Cells and Modules.** Distance between the nearest edges of stacks of munitions in adjacent cells and modules shall be as shown for appropriate explosives weights in Table C5.T1. When cell explosives loadings are established for weights other than those shown, minimum distances between stacks shall be determined by the formula distance = 1.1 times the cube root of the NEW in pounds ($D = 1.1W^{1/3}$).

C5.2.2.7.2. **Separation between Modules and All Other Targets**

C5.2.2.7.2.1. Distance between a module and other magazines shall be determined by applying the intermagazine distances specified in Table C9.T5.

C5.2.2.7.2.2. Distances between the explosives in the cells of a module and all other targets shall be determined upon the basis of the NEW of single cells. Distances shall be measured between the nearest edge of the munitions stack in the "controlling" cell and the nearest point of the target concerned (see paragraph C9.2.2.6. of Chapter 9).

C5.2.3. **Underground Magazines.** No specific limitation on NEW applies to these facilities or to individual chambers within facilities. Explosives limits will be based upon equations or table values in section C9.7., Chapter 9.

(Added after 319th Board Meeting)

C5.2.4. ***High Performance Magazines (HPM).*** *The primary objective of an HPM is to reduce the land encumbered by explosives safety quantity distances by limiting the maximum credible event (MCE) to a fraction of the total NEW stored in the HPM. Separation walls also provide protection against fire propagation between storage areas within the HPM. The HPM may be sited at the intermagazine distances as shown in Table C9.T5. Damage to assets depends on the donor NEW and the scaled separation distance K. Intermagazine distance provides nearly complete asset protection between HP Magazines (MCE = 60,000 lbs maximum). However, damage may occur to ammunition in an HPM to about K9 from a donor NEW > 350,000 lbs.*

C5.2.4.1 ***HP Magazine Storage Principles***

C5.2.4.1.1. Because of its construction, each storage cell of the HPM is treated as a separate magazine for the purposes of meeting DoD storage and compatibility requirements. For the purpose of storage within an HPM, all Hazard Division 1.1 and 1.2 ammunition is grouped into five HPM Sensitivity Groups as listed in the Joint Hazard Classification System (JHCS). Within a cell, all current mixing and storage compatibility regulations, as defined in Chapter 3, would apply.

C5.2.4.1.2. The five HPM Sensitivity Groups are:

C5.2.4.1.2.1. HPM Sensitivity Group 1—robust or thick-skinned

C5.2.4.1.2.2. HPM Sensitivity Group 2—non-robust or thin-skinned

C5.2.4.1.2.3. HPM Sensitivity Group 3—fragmenting

C5.2.4.1.2.4. HPM Sensitivity Group 4—cluster bombs/dispenser munitions

C5.2.4.1.2.5. HPM Sensitivity Group 5- other – items that are prohibited or items for which HPM nonpropagation walls are not effective (per JHCS)

C5.2.5.1.3. The allowable explosives weight in cells adjacent to cells

containing HPM Sensitivity Groups 1, 2, and 3 ammunition: 30,000 lbs in cell; 60,000 lbs in loading dock. The allowable explosives weight in cells adjacent to cells containing HPM Sensitivity Group 4 ammunition: 15,000 lbs in cell (side – side); 60,000 lbs in loading dock. (See High Performance Magazine Definitive Drawings: NFESC 99220001-99220012.)

C5.2.4.1.4 When HPM Sensitivity Groups are mixed, the most sensitive group controls the allowable explosives weight in an adjacent cell. When HD1.3, 1.4 and 1.6 are stored with HD1.1 or 1.2, the sensitivity groups of the HD1.1 and 1.2 control the storage requirements for explosives safety.

C5.2.4.1.5. For the purpose of assigning HPM Sensitivity Groups, an item should be placed into Group 1 when any two of the following criteria are met:

C5.2.4.1.5.1. explosive weight/empty case weight < 1

C5.2.4.1.5.2. case thickness > 0.4 inches

C5.2.4.1.5.3. case thickness/NEW$^{1/3}$ > 0.05 in/lb$^{1/3}$

C5.2.4.1.6. If an item does not meet the criteria shown above for Group 1 and it is not a candidate for Group 4 (cluster bombs/dispenser munitions), then, it should be considered for Group 2.

C5.2.4.1.7. Group 3 items have cases designed for fragmentation—items with pre-formed fragment warhead, scored cases, continuous rod warheads, etc. These items are usually air-to-air missile warheads.

C5.2.4.1.8. Items are assigned to Group 5 because of their sensitivity. Either it is known that the item can be very sensitive or the sensitivity of the item has not been established.

C5.2.4.1.9. Item specific testing and/or analyses can and should be used to change the HPM sensitivity group of an item.

C5.2.*5* **Other Magazines.** Existing magazines described by definitive drawings and specifically approved for the purpose by DoD Components are approved for storage of ammunition and explosives. Prior DDESB safety review and approval (section C5.6., below) are required for new types of ammunition and explosives storage facilities and for existing facilities first being proposed for use in storing ammunition and explosives.

C5.2.*6*. **Magazine Siting Requirements.** Magazines are sited relative to each other (that is, intermagazine distance) so that communication of explosion from one to another is unlikely. Actual siting requirements are influenced both by the construction features of the magazines and the types and quantities of ammunition and explosives they contain.

C5.2.6.1. If the specified thickness and slope of earth on magazines, as described

in paragraph C5.3.2.2., below, are not maintained, the magazine will be sited as an Unbarricaded, Aboveground Magazine.

C5.2.6.2. Magazines must not be structurally weakened such that their asset protection capability is reduced.

C5.2.6.3. The DoD Component performing a siting or analysis is to determine if the construction of a magazine being sited is equivalent to the requirements indicated on applicable drawings.

(Change approved at 321st Board Meeting)

C5.2.6.4. New construction of previously DDESB approved "7-Bar" and "3-Bar" ECM must meet the minimum requirements of the current revisions of the approved drawings.

C5.3. BARRICADES AND EARTH COVER FOR MAGAZINES

C5.3.1. General

C5.3.1.1. Properly constructed and sited barricades or undisturbed natural earth have explosives safety applications for protecting against low-angle fragments and for reducing shock overpressure loads near the barricade. If the barricade is destroyed in the process of providing that protection, then fragments from the destroyed barricade must also be considered as part of a hazards analysis.

C5.3.1.2. To reduce hazards from high-velocity, low-angle fragments, the barricade must be placed between the PES and the ES so that the fragments of concern impact the barricade before the ES. The barricade must be thick enough so that it reduces fragment velocities to acceptable levels and it must be high enough so that it intercepts the ballistic trajectories of the fragments of concern. Barricades are given no credit for providing protection against high-angle fragments

C5.3.1.3. A barricade placed between a PES and an ES interrupts the direct line-of-site motion of the shock wave. If the barricade has sufficient dimensions and is located close enough to the ES, significant reductions in shock loading to selected areas of the ES may be realized.

C5.3.2. Designs and Construction Materials

C5.3.2.1. Army drawing 149-30-01, December 22, 1991, shows several conceptual designs and construction materials for barricades.

C5.3.2.2. Materials for earthen barricades (including the earth-cover over magazines) shall be reasonably cohesive (solid or wet clay or similar types of soil may not be used as they are too cohesive) and free from deleterious organic matter, trash, debris, and stones heavier than 10 pounds or larger than 6 inches in diameter. The larger stones shall be limited to

the lower center of fills and shall not be used for earth cover over magazines. The earthen material shall be compacted and prepared, as necessary, for structural integrity and erosion control. If it is impossible to use a cohesive material, for example, in sandy soil, the barricade or the earth cover over magazines shall be finished with a suitable material to ensure structural integrity.

C5.3.2.3. Unless means are provided to control erosion, the slope of an earthen barricade must be 2 horizontal to 1 vertical. Presently approved earthen barricades having slopes no greater than 1-1/2 horizontal to 1 vertical remain approved.

C5.3.2.4. The earth fill or earth cover between ECM may be either solid or sloped, but a minimum of 2 feet or earth cover shall be maintained over the top of each magazine

C5.3.2.5. Underground storage facilities present special conditions that must be accounted for in portal barricade design. Specific criteria for location and construction of portal barricades for those facilities are found in subsection C5.3.5., below

C5.3.3. ***Protection Against High-Speed and Low-Angle Fragments.*** *For protection against high-velocity, low-angle fragments, determine the height, length, and location of a barricade, as follows:*

C5.3.3.1. ***Height.*** *Establish a reference point at the top of the far edge of one of the two stacks under consideration between which the barricade is to be constructed. That reference point, if the top of the stacks are not at the same elevation, shall be on the stack whose top is at the lower elevation. Draw a line from the reference point to the highest point of the other stack. Draw a second line from the reference point forming an angle of 2 degrees above the line. To preclude building excessively high barricades, the barricade should be located as close as possible to the stack on which the reference point was established. When the stacks are of equal height, the reference point may be established on either stack. (See Figure C5.F2.)*

C5.3.3.2. ***Length.*** *The length of the barricade shall be determined, as shown in Figure C5.F3.*

C5.3.3.3. ***Location.*** *For protection against high-velocity, low-angle fragments a barricade may be placed anywhere between the PES and the ES where conditions on its height and length are satisfied.*

C5.3.4. ***Overpressure Mitigation.*** *General procedures to predict pressure mitigation versus barricade design and location have not been developed. However, based on direct experimental work, the overpressure loading on a surface area shielded by a barricade is reduced by 50 percent when the following length, height, and location conditions are satisfied:*

C5.3.4.1. ***Location.*** *The barricade's standoff must be within two barricade heights of the protected area.*

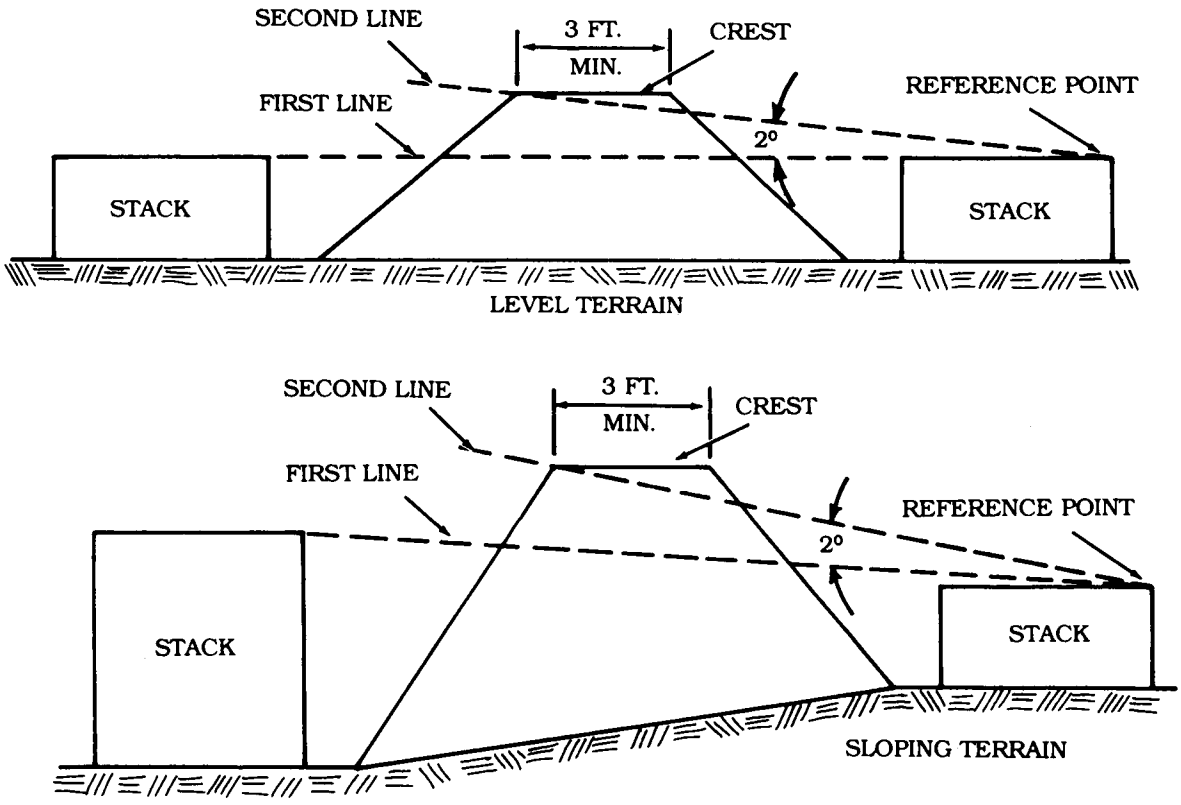


Figure C5.F2. Determination of Barricade Height

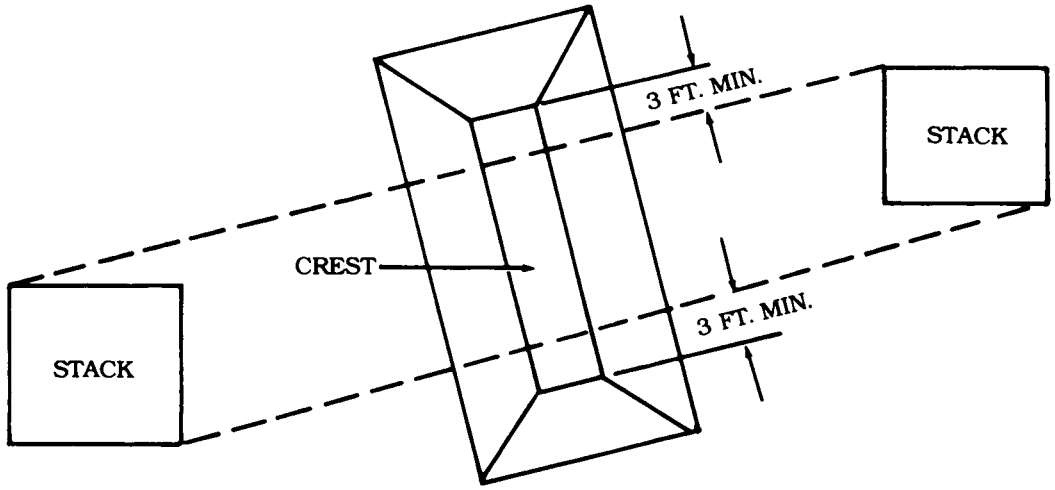


Figure C5.F3. Determination of Barricade Length

C5.3.4.2. **Height.** The top of the barricade must be at least as high as the top of *the protected area.*

C5.3.4.3. ***Width.*** *The width of the barricade must be at least two times the width of the protected area.*

C5.3.5. **Portal Barricades for Underground Magazines**

C5.3.5.1. Portal barricades for underground magazines are located immediately in front of an outside entrance or exit (that is, the portal) to a tunnel leading to an explosives storage point. The portal barricade should be centered on the extended axis of the tunnel that passes through the portal. Specific design criteria for a portal barricade are given in the Corps of Engineers definitive drawing number DEF 421-80-04. The remaining narrative of this paragraph is given for conceptual guidance. For maximum effectiveness, the front face (that is, the face toward the portal) of the barricade must be vertical and concave in plan, consisting of a central face oriented perpendicular to the tunnel axis, and wingwalls as shown in Figure C5.F4. The width of the central face typically equals the width of the tunnel at the portal. The wingwalls must be of sufficient width so that the entire barricade length intercepts an angle of ten degrees (minimum) to the right and left of the extended tunnel width. Likewise, the height of the barricade along its entire width must be sufficient to intercept an angle of ten degrees above the extended height of the tunnel.

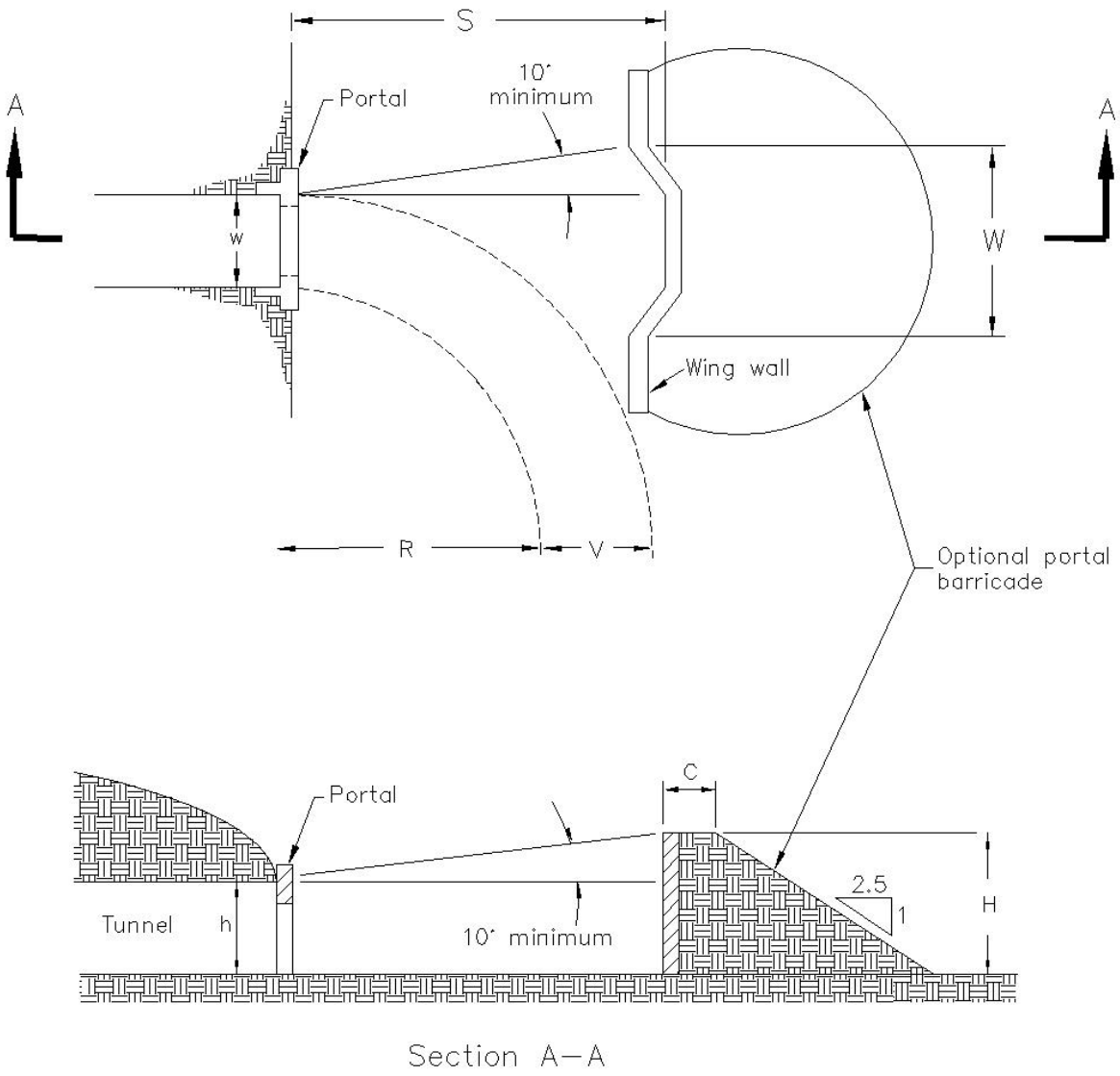
C5.3.5.2. Portal barricades for underground magazines must be located a distance of not less than one and not more than three tunnel widths from the portal. The actual distance should be no greater than that required to allow passage of any vehicles or materials handling equipment that may need to enter the tunnel. As shown in Figure C5.F4, this distance is based on the turning radius and operating width required for the vehicles or equipment.

C5.3.5.3. To withstand the impact of debris ejected from the tunnel; the front face of the portal barricade (including wingwalls) must be constructed as a wall of reinforced concrete, with a minimum thickness equal to 10 percent of the barricade height, but in no case less than 12 inches. The concrete wall must have a spread footing of sufficient width to prevent significant settlement, and the central wall, wingwalls, and footing must be structurally tied together to provide stability. The backfill behind the concrete wall may be composed of any fill material, including rock rubble from the tunnel excavation, with a maximum particle size of six inches within the area extending out to three feet from the rear face of the wall.

C5.3.6. **Earth-Filled, Steel Bin-Type Barricades (Armco Inc. Revetments or Equivalent) for Outside Storage**

C5.3.6.1. These barricades, also known as Armco Inc. revetments, are earth-filled steel bins used to separate munitions awaiting scheduled processing, for example, munitions on flight lines associated with aircraft parking/loading operations or the temporary positioning of munitions awaiting transfer to preferred, long-term storage. The barricades are also used to separate uploaded aircraft. These barricades are normally used to form a series of cells. The barricades are designed to limit the MCE (for Q-D siting purpose) of the munitions stored in

separate cells by preventing prompt detonation transfer to adjacent cells provided the munitions in each cell of the facility are properly positioned.



LEGEND:

S = Barricade standoff distance from portal
w, W = Tunnel width at portal and width of barricade (excluding wing walls)
V, R = Width and turning radius of munitions transport vehicles
h, H = Height of tunnel and height of barricade
C = Crest width

Figure C5.F4. Portal Barricade Location, Height and Length

C5.3.6.2. Armco Inc. revetments cells are approved for storage of any HD 1.1 and HD 1.2 AE assigned to Sensitivity Groups 1 through 4, as directed in C5.2.4.1. In addition, storage of HD 1.3, HD 1.4, or HD 1.6 items is approved.

C5.3.6.3. Armco Inc. revetments as sited in paragraph C5.3.6.4., below, should only be considered for preventing prompt detonation transfer, and that all munitions (and aircraft) in the series of cells are at risk of loss. In other words, although the revetments are effective in limiting the blast loading of adjacent ESs to that produced by the largest contents of a single cell, there is a significant probability that the contents of many cells will be damaged or destroyed by the initial and subsequent fire and explosion events. The extent of such losses increases with the amount of explosives present. Therefore, if valuable munitions and/or aircraft assets are to be preserved, then the quantities allowed in cells should be limited to satisfy valid essential operational requirements.

C5.3.6.4. There are two types of Armco Inc. revetments, Type A and Type B. Type A revetments must be a minimum of seven feet thick. Type B revetments must be a minimum of 5.25 feet thick. Type A Armco Inc. revetments may be used to limit the MCE in a series of cells to the largest quantity in a single cell if that quantity does not exceed 30,000 pounds NEW. Type B Armco Inc. revetments may similarly be used to limit the MCE, provided no cell contains more than 5,000 pounds NEW. The following conditions must be met.

C5.3.6.4.1. In addition to satisfying the criteria illustrated in Figures C5.F2. and C5.F3., munitions must be positioned no closer than ten feet from cell walls, no closer that three feet from the end of the wingwalls, and no higher than two feet below the top of cell walls.

C5.3.6.4.2. Munitions shall be positioned with the objective of distributing them over the available area within the cell, rather than concentrating them in the small area. The contents of a cell (stored in quantities near the maximum NEW limit) must not be configured into a single row of pallets, stacks, or trailers.

C5.3.6.4.3. Storage of munitions in inflammable outer-pack configurations must be minimized.

C5.4. **POLICY ON PROTECTIVE CONSTRUCTION**

Advances in protective construction permit achievement of any calculated level of protection from explosion communication between adjacent bays or buildings, for personnel against death or serious injury from incidents in adjacent bays or buildings, and for vital and expensive equipment installations. Therefore, the major objectives in facility planning shall be:

C5.4.1. Provision of protection against explosion communication between adjacent bays or buildings and protection of personnel against death or serious injury from incidents in adjacent bays or buildings (see subsection C9.2.2. of Chapter 9). When the protection of personnel and facilities would be greatly enhanced or costs reduced significantly by having separate buildings

to limit explosion propagation rather than using protective construction and separation of explosive units within one building, planning shall reflect this fact.

C5.4.2. Provision for protection of vital and expensive equipment, if the additional cost is warranted.

C5.4.3. When an appropriate degree of protection can be provided either by hardening a target building or construction of a source building to suppress explosion effects, these factors may be taken into account and the distance required by the standard Q-D tables may be reduced. Site and general construction plans for ammunition and explosives facilities that propose reduced distances based upon protective construction shall be accompanied by the rationale or test results that justify the reduction when they are submitted for DDESB approval (see section C5.6., below).

C5.5. **FACILITIES SITING CRITERIA**

This section establishes criteria for siting explosives and nonexplosives facilities with respect to PESs.

C5.5.1. **Administration, Industrial, and Convenience Areas**

C5.5.1.1. Administration and industrial areas shall be separated from PESs by inhabited building distances.

C5.5.1.2. Auxiliary facilities such as heating plants, line offices, break areas, briefing rooms for daily work schedules or site safety matters, joiner shops, security posts, and similar functions located at or near explosives operations and servicing only one building or operation shall be so located and constructed as to provide fire protection (See paragraph C2.4.1.7. of Chapter 2).

(Added as per 319th Board Meeting)

C5.5.1.3. Non-DoD explosives shall be separated from other non-DoD and DoD exposures according to Table C5.T4

C5.5.2. **Classification Yard**

C5.5.2.1. For protection of the classification yard from external explosions, separation distances shall be at least the applicable magazine distance.

C5.5.2.2. Specific Q-D separation is not required from the classification yard to targets other than explosives locations when the classification yard is used exclusively for:

C5.5.2.2.1. Receiving, dispatching, classifying, and switching of cars.

C5.5.2.2.2. Interchanging of trucks, trailers, or railcars between the

common carrier and the DoD activity.

C5.5.2.2.3. Conducting external inspection of motor vehicles or railcars, or opening of free rolling doors of railcars for the purpose of removing documents and making a visual inspection of the cargo.

C5.5.2.3. If the yard is used at any time for any purpose other than listed in paragraph C5.5.2.2., above, such as placing or removal of dunnage or explosives items into or from railcars, Q-D tables apply.

C5.5.3. **Areas for Burning Ammunition and Explosives.** Use the Q-D formula described in paragraph C9.2.2.1., Chapter 9 and the requirements in paragraphs C5.5.3.1. through C5.5.3.3., below, to determine safe locations for burning ammunition and explosives.

C5.5.3.1. Use a risk factor of K24 in the Q-D formula to determine the minimum safe distance for either personnel burning ammunition and explosives and/or those conducting unrelated ammunition operations.

(*Changed by correspondence July 5, 2000*)

C5.5.3.2. Use a risk factor of K40 in the Q-D formula to determine the safe distance for persons not performing ammunition operations. However, if the NEW of burn material is more than *450* pounds, the minimum safe distance shall be at least 1,250 feet. *If the NEW of burn material is less than 450 pounds, use the minimum hazardous fragment distances given by Table C2.T1.*

C5.5.3.3. Locate burning grounds at intraline distance from other PESs.

C5.5.4. **Ranges Used for Destruction of Ammunition, Demonstrations, and Explosive Ordnance Disposal (EOD)**

C5.5.4.1. The minimum separation distances between ranges (where explosives demolitions, demonstrations, and EOD explosives operations are conducted) and non-essential personnel are determined by application of the criteria given below. If the minimum separation distance requirements for previously approved DDESB sitings or those prescribed in this section cannot be met, then personnel shall be provided with protection as specified in subsection C4.3.2., Chapter 4.

C5.5.4.1.1. Distance (Feet) = 328 $W^{1/3}$, but not less than 1,250 feet, for non-fragmenting explosive materials. If known, maximum debris throw ranges, with an applicable safety factor, may be used to replace the 1,250 feet minimum range.

(Changed by correspondence July 5, 2000)

C5.5.4.1.2. Use the larger of these two distances: Those given by the equation

Distance (Feet) = 328 $W^{1/3}$ or those given in Table C5.T2 for the appropriate diameter, with a minimum distance of 1250 feet. A calculated or measured maximum fragment throw range (including the interaction effects for stacks of items or single items, whichever applies), with an appropriate safety factor, may be used to replace the distances given in Table C5.T2. Table C5.T3. presents calculated case fragment maximum throw ranges for selected item detonations. Those ranges were determined using the procedures given in Reference (an). Those calculated case fragment throw ranges are for individual items and do not apply to stacks of munitions. They also do not address "rogue" fragments produced by sections of nose plugs, base plates and/or lugs. "Rogue" fragments can travel to significantly greater distances (ranges greater than 10,000 feet) than those shown in Table C5.T3. Care must be taken either to properly orient the item or to take other efforts to minimize or eliminate this effect. Note: Items shall always be sited so that lugs and/or strongbacks and nose and/or tail plate sections are oriented away from personnel locations. When detonations involve multiple rounds, the preferred approach is as follows: (1) munitions shall be placed in a single layer with their sides touching such that their axis is horizontal; (2) the munitions shall be placed so that the nose of each munition is pointing in the same direction; (3) munitions shall be oriented so that lugs and/or strongbacks and nose and/or tail plate sections (rogue fragments) are facing away from areas to be protected; (4) the consolidated shot shall be initiated in such a manner that detonation of all munitions is simultaneous. When these procedures are not followed but the orientation of the rogue fragments can be controlled, then the ranges given in Tables C5.T2. and C5.T3. must be increased by 20% to account for interaction effects. When multiple rounds are arranged in stacks in which the orientation of individual items cannot be controlled, fragment ranges must be evaluated on a case-by-case basis. When detonations involve stacks of mixed munition types, evaluate the ranges for each type separately using the procedures just presented and use the larger of the ranges that are obtained.

Table C5.T2. Default Case Maximum Fragment Ranges for Intentional Detonations

DIAMETER (in)	MAXIMUM FRAGMENT RANGE (feet)	DIAMETER (in)	MAXIMUM FRAGMENT RANGE (feet)
		10.5	4408
<1.5	1250	11.0	4548
1.5	1266	11.5	4681
2.0	1626	12.0	4809
2.5	1905	12.5	4931
3.0	2133	13.0	5049
3.5	2326	13.5	5162
4.0	2493	14.0	5271
4.5	2641	14.5	5376
5.0	2772	15.0	5478
5.5	2892	15.5	5576
6.0	3000	16.0	5671
6.5	3101	16.5	5763
7.0	3193	17.0	5853
7.5	3400	17.5	5940
8.0	3593	18.0	6024
8.5	3775	18.5	6106
9.0	3946	19.0	6186
9.5	4108	19.5	6264
10.0	4262	20.0	6340

Notes

1. These calculated fragment throw ranges are for individual items and do not apply to stacks. They also do not address "rogue" fragments produced by sections of nose plugs, base plates and/or lugs. Those non-case fragments can travel to significantly greater distances than those shown in this table (distances greater than 10,000 feet). Care must be taken to properly orient the item or take other measures to minimize or eliminate this effect.

2. Maximum Fragment Range = 759 + 1251*[ln (Diameter)]; Diameter $\leq$ 7 inches; Diameter = exp[(Maximum Fragment Range/1251) - 0.61]; Range $\leq$ 3193 feet; Maximum Fragment Range in feet, Diameter in inches; ln is natural logarithm.

3. Maximum Fragment Range = -2641 + 2998*[ln (Diameter)]; Diameter > 7 inches; Diameter = exp (Maximum Fragment Range/2998) + 0.88]; Range > 3193 feet; Maximum Fragment Range in feet, Diameter in inches; ln is natural logarithm.

4. Use of equations given in Notes (2) and (3) to determine other Diameter-Maximum Fragment Range combinations is allowed.

5. See Paragraph C5.5.4.1.2. for ranges associated with multiple round detonations

Table C5.T3 Maximum Case Fragment Ranges for Selected Single Item Detonations

Munition	Maximum Fragment Throw Range (Case Fragments) (feet)
20 mm projectile	320
25 mm projectile	760
37 mm projectile	980
40 mm projectile	1100
40 mm grenade	345
M229, 2.75" rocket	1375
M48, 75 mm projectile	1700
M1, 105 mm projectile	1940
Mk 35, 5"/38 projectile	2205
Mk 64, 5"/54 projectile	1800
M107, 155 mm projectile	2580
M437, 175 mm projectile	2705
M106, 8-inch projectile	3290
Mk 13 and Mk 14 16"/50 Projectile	5640
M49A3, 60 mm mortar	1080
M374, 81 mm mortar	1235
M3A1, 4.2-inch mortar	1620
M64A1, 500-lb bomb	2500
Mk 81, 250-lb bomb	2855
Mk 82, 500-lb bomb	3180
Mk 83, 1000-lb bomb	3290
Mk 84, 2000-lb bomb	3880
BLU-109 bomb	4890

NOTES

1. *These calculated fragment throw ranges are for individual items and do not apply to detonationsinvolving multiple rounds. See paragraph C5.5.4.1.2. for application to multiple rounddetonations.*

2. *These ranges do not address "rogue" fragments produced by sections of nose plugs, base platesand/or lugs. Those non-case fragments can travel to significantly greater distances than thoseshown in this table (distances greater than 10,000 feet). Care must be taken to properly orientthe item to minimize or eliminate this effect.*

3. *Ranges shown are for case fragments. Shaped charge jets or slugs can go to significantly greaterdistances.*

C5.5.4.2. **Separation Distances for EOD Operations**

C5.5.4.2.1. EOD operational incidents involving threat devices require the application of public withdrawal distances to all non-essential personnel as prescribed in Table C8.T2.

C5.5.4.2.2. EOD operations and/or demonstrations conducted on ranges require minimum non-essential personnel separation distances defined in paragraph C5.5.4.1., above.

C5.5.4.2.3. Essential personnel conducting EOD training operations, or operations involving demolition of explosives and ammunition, do not require minimum separation distances. Protection of these individuals shall be determined by competent on-site authorities.

C5.5.4.2.4. EOD training ranges to maintain EOD proficiency are limited to a maximum of 5 lb of demolition explosives (bare charges or items without a fragment hazard). The ranges are to be constructed and sited as follows:

C5.5.4.2.4.1. The destruction point must be at least 500 feet from all other facilities, such as those with inhabited building, public traffic route, or intraline distance requirements.

C5.5.4.2.4.2. If the destruction point separation distance cannot satisfy the 500 feet requirement described above, then the separation distance may be reduced to 300 feet if the range is limited to 2.5 lb, or 200 feet if the range is limited to 1.25 lb of demolition explosives. Destruction points located with these reduced distances must be barricaded as follows:

C5.5.4.2.4.2.1. A barricade is to be constructed within 10 feet of the destruction point to control ejection of debris. It must be the equivalent of two sandbags thick and at least six feet high.

C5.5.4.2.4.2.2. The barricade must have two entrances opposing each other at 180 degrees separation. Each entrance must have a barricade equivalent to two sandbags thick and be long enough to effectively block all fragments and blast.

C5.5.4.2.4.3. If a training range is used for operations that will produce fragments above the level expected for normal EOD proficiency training (normally open shots), then the range must satisfy the requirements of paragraph C5.5.4.1., above.

C5.5.4.2.4.4. The range distance may be reduced to 100 feet if the EOD training is done using explosively operated tool kits. In this case, the site must be barricaded as described above, and only inert ammunition items used for training.

C5.5.4.3. Due to ballistic uncertainties for impact locations of various weapons and delivery systems, where demonstrations involve live fire exercises, range safety considerations shall be determined on a case-by-case basis by competent test authorities.

C5.5.4.4. Protective structures for personnel or measures taken to suppress blast and/or fragment effects, at disposals and demonstrations, may be used to reduce the required withdrawal distance.

C5.5.4.5. The minimum separation distances for essential personnel at disposal operations and demonstrations are to be determined by applicable authorities on site. These authorities shall also determine who are essential personnel.

C5.5.4.6. Control sites for ammunition and explosives destruction, demonstration, and EOD operations must be at intraline distance from other PESs based on the PES NEW.

C5.5.5. **Inert Storage Area.** The DoD Component concerned shall determine the acceptable protection for such areas after consideration of the value and importance of material in relation to the mission of the installation, the operational conditions, and the availability of space.

C5.5.6. **Interchange Yards.** Truck, trailer, or railcar interchange yards are not subject to Q-D regulations when they are used exclusively:

C5.5.6.1. For the interchange of vehicles or railcars containing ammunition and explosives between the commercial carrier and DoD activities.

C5.5.6.2. To conduct external inspection of the trucks, trailers, or railcars containing ammunition and explosives.

C5.5.6.3. To conduct visual inspection of the external condition of the cargo in vehicles (such as trucks, trailers, and railcars) that passed the external inspection. If the yards are used at any time for any purpose other than above, applicable Q-D tables apply (see paragraph C9.2.2.7., Chapter 9).

C5.5.7. **Inter-Service Support and Tactical Facilities.** Application of Q-D standards between inter-Service support facilities and for inter-Service tactical facilities.

C5.5.7.1. **General**

C5.5.7.1.1. Appropriate safety distances as provided in paragraph C5.5.7.2., below, shall be applied between facilities of one Military Service to facilities of another Military Service regardless of the location of the boundary between the two Service installations.

C5.5.7.1.2. Safety criteria based on toxicity, noise, thermal radiation, flight trajectory, fragmentation, incendiary, or other hazards may be greater than explosives safety distance criteria, in which case the criteria based on the predominant hazard shall be considered.

C5.5.7.2. The following Q-D relationships shall apply to the separation of facilities of two Services:

C5.5.7.2.1. Explosives storage facilities of one Military Service shall be separated from explosives storage facilities of another Military Service, as a minimum, by appropriate intermagazine distance.

C5.5.7.2.2. Explosives storage or operating locations of one Military Service shall be separated from explosives operating locations of another Service by appropriate inhabited building distance. When operations in each facility present a similar degree of hazard or for joint or support operations, this separation may be reduced to the appropriate intraline distance.

C5.5.7.2.3. Explosives storage or operating locations of one Military Service shall be separated from explosives tactical facilities of another Service by appropriate inhabited building distance. For joint or support operations, use the appropriate separation distance as though both facilities belonged to a single Military Service.

C5.5.8. **Loading Docks.** Detached loading docks which normally service multiple facilities shall be sited on the basis of use. When servicing magazines, they must be separated from the magazines by intermagazine distances. When servicing operating buildings, they must be separated from the operating buildings by intraline distances.

C5.5.9. **Railcar and Truck Holding Yards**

C5.5.9.1. Generally, railcar holding yards shall be laid out on a unit railcar-group basis with each group separated by the applicable aboveground magazine distance.

C5.5.9.2. If the railcar holding yard is formed by two parallel ladder tracks connected by diagonal spurs, the parallel tracks and the diagonal spurs shall be separated by applicable aboveground magazine distance for the unit-group quantities of HE.

C5.5.9.3. If the railcar holding yard is a "Christmas tree" arrangement, consisting

of a ladder track with diagonal dead-end spurs projecting from each side at alternate intervals, the spurs shall be separated by the applicable aboveground magazine distance for the net weight of high explosives in the railcars on the spurs.

C5.5.9.4. Generally, truck holding yards shall be laid out on a unit truck-group basis with each group separated by the applicable aboveground magazine distances.

C5.5.9.5. Both railcar and truck holding yards shall be separated from other facilities by the applicable IBD, PTR, ILD or IMD Q-D criteria.

C5.5.9.6. In addition to the temporary parking of railcars, trucks, or trailers containing ammunition and explosives, holding yards may also be used to interchange truck, trailers or railcars between the commercial carrier and the DoD activity and to conduct visual inspections.

C5.5.10. **Railcar and Truck Inspection Stations**

C5.5.10.1. Specific Q-D separations are not required for inspection stations; however, they should be as remote as practicable from hazardous or populated areas. Activities that may be performed at the inspection station after railcars or motor vehicles containing ammunition and explosives are received from the delivering carrier and before further routing within the installation are:

C5.5.10.1.1. External visual inspection of the railcars or motor vehicles.

C5.5.10.1.2. Visual inspection of the external condition of the cargo packaging in vehicles (such as trucks, trailers, and railcars) that have passed the external inspection indicated in subparagraph C5.5.10.1.1., above.

C5.5.10.1.3. Interchange of trucks, trailers, or railcars between the common carrier and the DoD activity.

C5.5.10.2. If any activities other than the above are conducted at the inspection station, Q-D applies.

C5.5.10.3. Any railcars or trucks suspected of being in a hazardous condition shall be isolated consistent with applicable Q-D separation for the hazard class and explosives quantity involved. This shall be accomplished first, before any other later action.

C5.5.11. **Ammunition/Explosives Transportation Mode Change Locations.** Movement and transfer of DoD-titled ammunition and explosives must be in compliance with national, international, and host country-specific transportation regulations. Q-D criteria apply to all transfer operations involving DoD-titled ammunition except for:

C5.5.11.1. Roll-on/roll-off operations (not involving lifting); and,

C5.5.11.2. Off-installation MILVAN/ISO container inter-/intramodal transfers (involving highway and rail modes only) where containers are not stored or other operations are performed.

C5.5.12. **Recreational and Training Facilities.** Open areas between explosives storage and handling sites and between these sites and nonexplosives buildings and structures shall be controlled carefully regarding use for recreation or training facilities. As a general rule, the fragment hazard will be severe from the explosion site out to approximately the public traffic route distances. Accordingly, recreation and training facilities, where civilian employees, military and civilian dependents, or the public are in the open, shall be sited at not less than public traffic route distances and at or as near inhabited building distances as practicable. When structures, including bleachers, are included as part of these facilities, they shall be sited at not less than inhabited building distances.

C5.5.13. **Storage Tanks for Hazardous Materials**

C5.5.13.1. Large permanent storage facilities are of primary concern when applying quantity-distance (Q-D) criteria to storage tanks. For installation of smaller tanks, it may be desirable to *weigh the cost of distance and/or protective construction against the strategic value of the stored* material, the ease of replacement in the event of an accident, and the potential environmental impact. Reduced distances may be approved if these losses are accepted by the DoD Component, if the tanks are sited and if spill containment is provided so other exposures are not endangered.

C5.5.13.2. Small quantities of POL and other hazardous materials used for operational purposes require no specific separation distance for explosives safety; however, operating procedures must be implemented to limit adverse environmental impacts in the event of an accidental explosion.

C5.5.13.3. Unprotected, aboveground storage tanks shall be separated from other PESs at IBD per Table C9.T1., as a minimum, and shall be diked.

C5.5.13.4. Unprotected service tanks, which provide sole support to aboveground explosives storage and operating complexes, and are supplied by a pipe system designed to resist potential blast and fragments, may be sited at incremented K40/K50 inhabited building distance with a minimum distance of 400 feet, provided:

C5.5.13.4.1. A dike system, meeting the requirements in NFPA 30, (reference (j)) is provided; and,

C5.5.13.4.2. The Service accepts the possible loss of the tanks and any collateral damage that a fire might cause as a result of the tanks being punctured by fragments.

C5.5.13.5. A service tank supporting a single PES shall be separated, at a

minimum, from that PES at the appropriate NFPA fire protection distance. The distance from this service tank to any other PES will be the larger of the required distance between the PESs or the appropriate NFPA fire protection distance.

C5.5.13.6. Distances less than those for unprotected tanks may be used when an aboveground storage tank is provided sufficient protection from blast and fragment hazards to prevent rupture or collapse.

C5.5.13.7. Buried tanks and buried pipelines should be separated from aboveground buildings or stacks containing ammunition or explosives of Hazard Divisions 1.2, 1.3 and 1.4 by a minimum distance of 80 feet. The required separation distance for ammunition in Hazard Division 1.1 is K3 with a minimum of 80 feet.

C5.5.13.8. It is not practical to specify Q-D criteria that cover all configurations involving tank storage and underground ammunition storage facilities. Each case must be assessed on a site specific basis to take account of crater, blast, ground shock, debris hazards and potential, adverse environmental impacts.

C5.5.14. **Storage Tanks for Water**

C5.5.14.1. Loss of tank is unacceptable: Q-D for unprotected aboveground storage tanks in this category shall meet the siting requirements of paragraph C5.5.13.3., above. Buried tanks and associated components of like value shall meet the siting requirements of paragraph C5.5.13.7., above.

C5.5.14.2. Loss of tank is acceptable: Q-D criteria do not apply to storage tanks and associated components in this category.

C5.5.15. **Underground Tanks or Pipelines for Non-Hazardous Materials.** These should be separated from buildings or stacks containing ammunition and explosives of Hazard Divisions 1.2 through 1.4 by a minimum distance of 80 feet. The separation for Hazard Division 1.1 shall correspond to the formula $D = 3W^{1/3}$ with a minimum distance of 80 feet, unless the donor building is designed to contain the effects of an explosion.

C5.5.16. **Wharf Yard.** Separation of a wharf yard from the pier which it serves by a distance clearly sufficient to prevent immediate propagation of an explosion ($11W^{1/3}$) will be impracticable in many cases. In such cases, the wharf yard will be considered as part of the ship or barge unit and added to it for computation of the total amount of explosives for Q-D purposes. The outer limit of the wharf yard then shall be considered as the ship unit boundary for computing applicable Q-D requirements.

C5.5.17. **Parking Lots.** Parking lots for privately owned automobiles belonging to personnel employed at or stationed at multiple PESs shall be sited at intraline distance from each PES. When a parking lot supports a single PES, it may be separated at less than intraline only from its associated facility. A minimum distance of 100 feet is required to the associated facility to protect it from vehicle fires. Access for emergency vehicles must be provided. Parking lots

for administrative areas shall be located at public traffic route distance from all PESs (minimum fragment distance shall apply).

C5.5.18. **Helicopter Landing Areas.** Helicopter landing areas for loading and unloading ammunition within storage sites and quick reaction alert sites shall be considered aboveground magazines and may be sited at appropriate quantity distances based only upon explosives carried by the helicopter(s). Intermagazine distances shall apply to magazines and maintenance buildings subject to the following requirements:

C5.5.18.1. Flight clearance criteria are met.

C5.5.18.2. Landing and takeoff approaches shall not be over magazines.

C5.5.18.3. Helicopter operations are to be limited to ammunition support of the magazines concerned. Carrying passengers is not permitted.

C5.5.18.4. Safety precautions normal to other modes of transportation, are to be observed. Explosives operations shall not be conducted in the magazines or maintenance buildings located within inhabited building distance from the helicopter landing area during takeoff, landing, or loading and/or off-loading of the helicopter(s). Those maintenance buildings and magazines shall be closed.

C5.5.19. **Temporary Construction Operations**. Construction personnel who must, on a temporary basis, be near PESs to perform their job shall be provided the maximum practicable protection from the effects of an explosion should one occur at a PES. The DoD Component concerned shall determine the minimum practicable distance from which such personnel will be separated from PESs and shall control operations at the PESs so that the chance of an explosion occurring is kept to a minimum. Documentation showing the rationale for control measures taken shall be maintained until operations have been completed and personnel have permanently vacated the work site.

(Added by 322nd Board Meeting)

C5.5.20. **Secure Holding Area**. An area designated for the temporary parking of commercial carriers' motor vehicles transporting DoD-owned Arms, Ammunition, and Explosives (AAE), classified (SECRET or CONFIDENTIAL) materials, and CCI. There are two types of secure holding areas and the criteria for each are provided below. **(Note**: Although the intent of such areas is to provide a secure storage location for commercial carriers while in-transit, or during emergencies or other circumstances that are beyond a carrier's control, this Standard imposes no requirement for installations to have such areas. The term Secure Holding Area is applicable to areas (CONUS, Hawaii, Alaska, and Puerto Rico) governed by reference (ar)).

C5.5.20.1. **Secure Explosives Holding Area**. Site as a holding yard per C5.5.9 above.

C5.5.20.2. **Secure Non-explosives Holding Area**. No siting required if located outside all QD arcs. If located within a QD arc, site per C5.5.17 above. The holding of HD 1.4S materials, without regard to QD, is permitted at this location.

C5.6. SITE AND GENERAL CONSTRUCTION PLANS REVIEW

C5.6.1. In accordance with DoD Directive 6055.9 (reference (k)), site and general construction plans for ammunition and explosives facilities as well as plans for changes in utilization of facilities or mission changes that adversely affect the explosives Q-D requirements shall be submitted to the DDESB for review and approval. Plans shall be forwarded for:

C5.6.1.1. New construction or major modifications of facilities for ammunition and explosives activities. Modifications or rehabilitation plans for existing facilities do not require submission to DDESB when the plans do not introduce additional hazards or do not increase the net explosives capacity or chemical agent hazard for which the facility was designed or sited.

C5.6.1.2. Facilities for activities not involving ammunition or explosives that are in such proximity to ammunition and explosives as to be exposed to hazards or for which a reasonable doubt may exist regarding possible exposure to hazards.

C5.6.1.3. Facilities for activities not involving ammunition and explosives that become exposed to blast, fire, or fragment hazards; or potential toxic chemical agent release due to change in installation mission or facilities usage. For example, an airfield restricted to DoD Component use only being changed to joint DoD and non-DoD use.

C5.6.2. When the review of site and general construction plans is required, the DoD Component concerned shall:

C5.6.2.1. Indicate specifically in the letter of transmittal its approval of the proposal, along with changes, modifications, or specific precautionary measures considered necessary.

C5.6.2.2. Submit drawings of site plans at a scale of 1 inch equals not more than 400 feet. Drawings of a smaller scale than that specified may be necessary periodically to properly reflect certain distance and structure relationships within the area surrounding a given project. A reduction in scale in such instances is acceptable. When standard drawings (definitive) for a building or group of buildings exist that have been reviewed by the DDESB and declared acceptable, the definitive drawings are not required. In these cases, only a site plan is required noting the definitive drawings for each building or structure to be constructed.

C5.6.2.3. Indicate distances between the facility to be constructed or modified and other installation facilities, the installation boundary, public railways, and public highways, including power transmission and utility lines.

C5.6.2.4. Identify all other facilities including their occupancy and use within inhabited building distance of the facility to be constructed or modified.

C5.6.2.5. Provide descriptions of hazardous materials or items to be in the new or modified facilities such as, bombs, rockets, artillery ammunition, chemical agents, nuclear weapons, liquid propellants, or other items requiring protective measures in accordance with this Standard. Include results of tests to determine blast, fragmentation, and thermal hazards.

C5.6.2.6. Indicate quantities, classes, and divisions of ammunition, explosives, chemical agents, liquid and solid propellants, or other hazardous material proposed for the new or modified facility.

C5.6.2.7. Provide anticipated personnel limits for the new or modified facility, including a breakdown by room or bay when appropriate.

C5.6.2.8. Provide general details regarding dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, hazardous waste disposal systems, lightning protection system, static grounding systems, process equipment, and auxiliary support structures as well as general materials of construction, unless approved drawings are being used.

C5.6.2.9. Provide a brief summary of the design procedures used if engineered protection is used to reduce the Q-D. This summary shall include a statement of the design objectives in terms of protection categories (as defined in TM 5-1300, NAVFAC P-397, and AFM 88-22, (reference(g))) to be obtained, explosives quantities involved, design loads applied, material properties and structural behavior assumptions, references, and sources of methods used. Detailed calculations are not required provided the protective designs used to reduce Q-D have been approved by the DDESB. Design of explosion resistant facilities shall be accomplished by an organization or individual experienced in the field of structural dynamics using design procedures accepted by professionals in the field. An appropriate source of effects data and design methods for explosion resistance is TM 5-1300, NAVFAC P-397, AFM 88-22, (reference (g)).

C5.6.2.10. Furnish information on the type and arrangement of explosives operations or chemical processing equipment.

C5.6.2.11. Provide a topography map with appropriate contours when terrain features are considered to constitute natural barricading, or topography otherwise influences layout as in some chemical operations.

C5.6.2.12. Provide, in addition to the above and when chemical agents are involved, information regarding personnel protective clothing and equipment, treatment of effluent and waste materials to ensure absence of chemical agents, adequacy of medical support, average wind speed and direction, other support facilities pertinent to chemical safety, warning and detection systems, and hazard analysis, as appropriate.

C5.6.2.13. Explain any deviations from pertinent safety standards caused by local conditions.

C5.6.3. The information in subsection C5.6.2., above, shall be submitted as follows:

C5.6.3.1. Preliminary site plan approval (paragraphs C5.6.2.1. through C5.6.2.7. and C5.6.2.13., above).

C5.6.3.2. Final safety review (paragraphs C5.6.2.1. through C5.6.2.13., above).

C5.6.4. A copy of the complete site plan and the final safety submission, together with DDESB letter(s) of approval, must be retained as a permanent record at the installation of origin. This information may be subject to review during future DDESB surveys. *Installation maps and drawings showing quantity-distance arcs shall be kept current with the latest site plan approvals and reconciled with the Installation's Master Planning Documents.*
(Added by 322nd Board Meeting)

C5.6.5. Site plans are not required to be submitted to the DDESB for the specific situations listed below. Components will specify siting and documentation requirements for these situations.

C5.6.5.1. Storage and associated handling of HD 1.4S (see C3.4.13. and C9.3.4.2).

C5.6.5.2. Interchange yards limited to those operations described in C5.5.6.

C5.6.5.3. Inspection stations where only the operations described in C5.5.10 are performed.

C5.6.5.4. Transportation mode change locations, which involve roll-on/roll-off operations where no lifting is involved, and for off-installation MILVAN/ISO container inter-/intramodal transfers (involving highway and rail modes only) where containers are not stored or other operations are performed (see C5.5.11).

C5.6.5.5. Parking of aircraft loaded with specific munitions (see C9.4.1.2), while in designated aircraft parking areas that meet airfield criteria, and associated handling of these munitions, provided the quantity of munitions involved in the operation is limited to a single aircraft load.

C5.6.5.6. The handling of HD 1.3 and HD 1.4 material (300 pounds NEW or less) necessary for ships' security and safety-at-sea (see C9.5.1).

C5.6.5.7. Storage of limited quantities of HD 1.2.2, HD 1.3, or HD 1.4, for reasons of operational necessity, as permitted by C9.3.2.10 and applicable notes of Tables C9.T10 and C9.T11.

C5.6.5.8. Certain contingency and combat training operations as described in C10.4.

(Added after the 319th Board Meeting)

C5.7. CRITERIA FOR NON-DOD EXPLOSIVES ACTIVITIES ON DOD NSTALLATIONS

C5.7.1. The non-DoD activity will be evaluated based on intermagazine distance between multiple PESs to insure non-propagation. Where intermagazine distance is not met, then the non-DoD sites will be added to determine the applicable intermagazine distance or inhabited building distance to DoD sites.

C5.7.2. In Table C5.T4, "Check for IM" means if intermagazine distance is not maintained between each PES, explosives quantities will be totaled.

C5.7.3. IBD will be determined based on this Standard.

C5.7.4. The DoD site approval for non-DoD operations and storage will be limited to a "footprint" only. The footprint will be the area included by the IBD arc(s) determined.

C5.7.5. Review of building design, lightning protection, etc, is not necessary unless design features are used to reduce the IBD arc.

Table C5.T4. Criteria for Non-DoD Explosives Activities on DoD Installations

To ➔ From ⬇	Non-DoD Storage	DoD/Joint Storage	Non-DoD Operations	DoD Operations	Shared Launch Facilities	DoD Non-Explosives Facilities/Operations Non-Related
Non-DoD Storage	Check for IM	IM	Check for IM	IBD	IBD	IBD
Non-DoD Operations	Check for IM	IBD	Check for IM	IBD	IBD	IBD
Shared Launch Facilities	IBD	IBD	IBD	IBD	IL	IBD
DoD/Joint Storage	IM	IM	IBD	IL	IBD	IBD
DoD Operations	IBD	IL	IBD	IL	IBD	IBD

Definitions:

***DoD Operations/Storage**: Explosives operations conducted by DoD, or other federal agency, under DoD oversight, procedure, or control and in accordance with the explosives safety standards of DoD 6055.9-STD. This term is applicable only to DoD and federal explosives operations, and to non-DoD commercial enterprises directly supporting DoD and federal explosives contractual efforts.*

Non-DoD Operations/Storage*: Explosives operations/storage conducted on DoD property in accordance with only this table, BATF, FAA or other federal, state, and local explosives safety requirements. Under these type operations, DoD will be responsible only for insuring IM standards are met as outlined in explosives site plan submissions. This does not constitute "DoD oversight" as intended in the above definition of "DoD Operations/Storage."*

Shared Launch Facility*: Any space or orbital launch facility that supports both DoD and non-DoD launch services and operations, as determined by service involved or by mutual agreement when multiple DoD military services are involved.*

Joint Storage*: DoD/non-DoD explosives storage under DoD control.*

C6. CHAPTER 6 ELECTRICAL STANDARDS

C6.1. GENERAL

The National Electrical Code, published by the National Fire Protection Association as NFPA 70 (reference (l)), does not specifically address explosives; however, Article 500 of the Code, Hazardous (Classified) Locations, does establish standards for the design and installation of electrical equipment and wiring in atmospheres containing combustible dusts and flammable vapors and gasses that, in general, are comparably hazardous. Exceptions are extraordinarily hazardous explosives, such as nitroglycerin, that require special consideration, including physical isolation from electric motors, devices, lighting fixtures, and the like. National Electrical Code standards and this Chapter are minimum requirements for DoD buildings and areas containing explosives.

C6.2. HAZARDOUS LOCATIONS

National Electrical Code definitions of Class I, Division 1, and Class II, Division 1, hazardous locations are modified as follows for DoD explosives applications:

C6.2.1. Areas containing explosives dusts or explosives that may through handling produce dust capable of being dispersed in the atmosphere shall be regarded as Class II, Division 1, hazardous locations.

C6.2.2. Areas in which explosives sublimation or condensation may occur shall be regarded as both Class I, Division 1, and Class II, Division 1, hazardous locations.

C6.3. SPECIAL OCCUPANCIES

C6.3.1. To ensure assignment to the proper hazardous location, class and group, it is necessary to have knowledge of the properties of explosives involved. Minimum requirements include sensitivity to heat and spark and thermal stability. If the properties of an explosive are such that Class I or Class II, or both, provide inadequate protection under prevailing conditions, use of any of the following approaches is acceptable: intrinsically safe equipment, purged or pressurized and suitably temperature-limited equipment, exclusion of electrical equipment from the hazardous atmosphere, or isolation of equipment from the hazardous atmosphere by means of dust, vapor, or gas-free enclosures with surface temperatures positively maintained at safe levels.

C6.3.2. **Underground Storage Facilities.** All wiring and electrical equipment in underground storage facilities must, in addition to any other requirements of this Chapter, be of moisture and corrosion resistant materials and construction unless a site specific analysis indicates that such construction is not necessary. Underground facilities must have emergency lighting systems to provide minimum illumination in the event of a power failure.

C6.4. **STATIC ELECTRICITY**

Personnel and equipment in hazardous locations (section C6.2., above) and locations where static sensitive electroexplosive devices (EEDs) are exposed shall be grounded in a manner to effectively discharge static electricity so as to prevent accumulations that are capable of initiating the dusts, gases, vapors, or exposed EEDs. Also, permanent equipment in contact with conductive floors and table tops are not to be regarded as adequately grounded. All grounds, including static grounds, shall be interconnected if a structure is equipped with a lightning protection system.

C6.5. **ELECTRIC SUPPLY SYSTEMS**

There may be mutual hazards when PESs are located near electric supply lines. To protect against these hazards, the following separation requirements apply to all new construction:

C6.5.1. Electric lines serving explosives operating facilities shall be installed underground from a point not less than 50 feet away from such facilities.

C6.5.2. Overhead electric service lines shall be no closer to a potential explosion site (PES) of combustible construction or an open PES *than* the length of the lines, unless an effective means is provided to ensure that energized lines on breaking cannot come into contact with the facility or its appurtenances.

C6.5.3. Electric distribution lines (those carrying less than 69 KV), the tower or poles supporting those lines, and unmanned electrical substations shall be no closer to PESs than public traffic route distances.

C6.5.4. Electric transmission lines (those carrying 69 KV or more) and the tower or poles supporting them shall be located no closer to PESs than:

C6.5.4.1. Inhabited building distance if the line in question is part of a grid system serving a large off-base area.

C6.5.4.2. Public traffic route distance if loss of the line will not create serious social or economic hardships. (Public traffic route and inhabited building distances shall be based on airblast overpressure only; fragment distances will not be used.)

C6.5.5. Electric transmission lines which can be interrupted without loss of power, i.e., power is rerouted through existing lines and/or networks, will be separated from explosives sites in accordance with subsection C6.5.2., above.

C7. CHAPTER 7 LIGHTNING PROTECTION

C7.1. POLICY

This Chapter defines minimum explosives safety criteria for the design, maintenance, testing and inspection of lightning protection systems. Properly maintained lightning protection is required (with exceptions) for ammunition and explosives facilities. If other lightning protection systems for these facilities are used, they shall offer equivalent protection to the types prescribed in this Chapter.

C7.2. REFERENCES

Refer to the National Fire Protection Association Lightning Protection Code, NFPA 780 (reference (m)), the National Electrical Code, NFPA 70 (reference (l)), and MIL-HDBK-419 (reference (n)).

C7.3. LIGHTNING PROTECTION SYSTEM DESIGN

C7.3.1. **Lightning Protection Systems.** Lightning systems must feature air terminals, low impedance paths to ground, sideflash protection, surge suppression or grounding of all conductive penetrations into the protected area, and earth electrode systems. Structural elements of the building may serve as air terminals, down conductors, or the earth electrode. Lightning protection systems used to protect DoD ammunition must be designed to intercept lightning at a 100 ft or less striking distance arc in accordance with NFPA 780 (reference (m)).

C7.3.1.1. **Air Terminals.** An air terminal is a component of a lightning protection system that is able to safely intercept lightning strikes. Air terminals may include overhead wires or grids, vertical spikes, or a building's grounded structural elements. Air terminals must be capable of safely conducting a lighting strike.

C7.3.1.2. **Down Conductors.** Down conductors (flat or round) provide low impedance paths from the air terminals described above to the earth electrode (ground) system. Structural elements having a high current capacity and a low impedance to ground need not be augmented with wires. Where wires are used as down conductors, these shall meet the requirements of NFPA 780 (reference (m)).

C7.3.1.3. **Sideflash Protection.** Protection from side flash caused by lightning shall be obtained by either separation distance or bonding in accordance with NFPA 780 (reference (m)), except as modified herein.

C7.3.1.3.1. Fences and railroad tracks located within six feet of a structure's lightning protection system shall be bonded to the structure's lighting protection system.

C7.3.1.3.2. The reinforcing bars in adjacent structural elements must be joined in

a manner to provide electrical bonding between the elements. This is an absolute requirement for facilities that are used to store ammunition. Techniques commonly used and approved in the construction industry to join reinforcing steel are acceptable for this purpose. The steel arch of an earth-covered magazine must be similarly joined to the rebar in the floor.

C7.3.1.4. **Surge Protection for Incoming Conductors.** A lightning protection system shall include surge protection for all incoming conductors. The surge protection must include suppression at the entrance to the building from each wire to ground. Shielded cabling, power cabling, communication lines, and electrical conduit shall be buried underground in conduit for a minimum of 50 feet before entering the structure. All other metallic utility lines and pipes must be electrically connected to the lightning protection system or the structural steel of the building just before they enter the building.

C7.3.1.5. **Earth Electrode System.** Earth electrode systems dissipate the current from a lightning strike to ground. Earth electrode systems may be Ufer grounds, ground loop conductors, radials, grounding rods, ground plates, a cable immersed in nearby salt water, chemical grounds that are installed for the purpose of providing electrical contact with the earth, or combinations of these.

C7.4. INSPECTION, TESTING AND TRAINING

C7.4.1. **Visual inspection**. The lightning protection system shall be periodically inspected at a frequency determined by each Service. Visual inspections shall be conducted at least yearly.

C7.4.2. **Electrical tests**. The lightning protection systems shall be periodically tested electrically as specified in paragraphs C7.4.2.1. and C7.4.2.2., below. Electrical testing shall be accomplished at least every two years.

C7.4.2.1. **Bonding (Resistance) Tests.** Bonding (resistance) tests shall be conducted periodically (or after facility modification that may affect bonding). A maximum resistance value of one ohm is permitted across all bonds.

C7.4.2.2. **Resistance to Earth Tests.** Resistance to earth tests of the lightning protection system shall be conducted periodically during the same season of the year (or after facility modification that may have affected the system).

C7.4.3. **Records.** Records of resistance to earth tests shall be kept on file for the last six inspection cycles. These records shall be reviewed for trend analysis.

C7.4.4. **Training.** Personnel responsible for maintenance, inspection and testing must be familiar with the fundamentals described in NFPA 780 (reference (m)) and herein as they relate to explosives facilities to ensure requirements of subsections C7.4.1. and C7.4.2., above, are met.

C7.5. LIGHTNING PROTECTION EXCEPTIONS

Properly maintained lighting protection is required for ammunition and explosives facilities, with the follow exceptions:

C7.5.1. Explosives operations served by a local lightning warning system to permit operations to be terminated before the incidence of an electrical storm, if all personnel can and will be provided with protection equivalent to public traffic route distance, and the damage from a lighting strike is acceptable to the Military Service.

C7.5.2. Facilities containing only ammunition or explosives that cannot be initiated by lightning, as determined by the DoD Components concerned and approved by DDESB, and where no fire hazard exists.

C7.5.3. Facilities where personnel are not expected to sustain injury and at the same time, the resulting economic loss of the structure, its contents and/or surrounding facilities is minimal.

C8. CHAPTER 8 HAZARD IDENTIFICATION FOR FIRE FIGHTING AND EMERGENCY PLANNING

C8.1. SCOPE AND APPLICABILITY

C8.1.1. This Chapter establishes standard firefighting hazard identification measures to ensure a minimum practicable risk in fighting fires of ammunition and explosives. These identification measures are based on the classification of fires into four fire divisions according to the hazard they present. *This Chapter also establishes minimum guidelines for the development of emergency plans, including safety, security, and environmental protection, which have been coordinated with local authorities.*

C8.1.2. Firefighting procedures, training of firefighting personnel, the use and maintenance of firefighting equipment and vehicles, the provision of water supply and alarm systems, the first aid measures, and other measures required in firefighting are outside the scope of this Chapter and shall be the responsibility of the DoD Components.

C8.1.3. The ammunition hazard symbols and supplemental symbols including chemical agent symbols (see section C8.4., below) are for firefighting situations only and are not necessarily applicable to normal operating conditions.

C8.2. FIRE DIVISIONS

C8.2.1. The fire divisions are the same as Hazard Divisions 1.1 through 1.6 of Chapter 3 and are numbered serially from 1 to 6.

C8.2.2. Fire division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers from 1 to 4. Fire divisions 5 and 6 refer to explosion hazards from less sensitive substances and extremely insensitive articles, respectively.

Fire Division	Hazard involved
1	Mass explosion
2	Explosion with fragment hazard
3	Mass fire
4	Moderate fire
5	Mass explosion (blasting agents)
6	Nonmass explosion (EIDS article)

C8.3. FIRE DIVISION SYMBOLS

C8.3.1. The six fire divisions are indicated by four distinctive symbols in order to be recognized by the firefighting personnel approaching the fire scene. A fire division number is shown on each symbol. Because of similar firefighting hazards, the Fire Division 1 fire symbol and number are also used for Fire Division 5 and the Fire Division 2 fire symbol and number are

also used for Fire Division 6. For the purpose of identifying these symbols from long range, the symbols differ in shape as follows:

Shape	Fire Division Symbol
Octagon	1
Cross	2
Inverted triangle	3
Diamond	4

C8.3.2. The color of all four symbols is orange. The color of each number identifying the applicable fire division is black. This requirement is in accordance with the color on North Atlantic Treaty Organization (NATO), United Nations Organizations (UNO), and International Maritime Organization (IMO) labels for Class 1 (explosives).

C8.3.3. The shape and size of the four fire division symbols and numbers are shown in Figure C8.F1. For application on doors or lockers inside buildings half-sized symbols may be used.

C8.3.4. Posting of firefighting symbols on nuclear, chemical, or conventional weapon storage sites is at the discretion of the DoD Components. This recognizes that under some conditions security considerations may make it undesirable to identify munitions with fire symbols at the actual storage locations.

C8.3.5. At the option of the DoD Component concerned, supplemental symbols to indicate special hazards, such as those of toxic chemicals, may be used in addition to the firefighting symbols specified in this Chapter (see Figure C8.F3.).

C8.4. CHEMICAL AGENT AND AMMUNITION HAZARD SYMBOLS

C8.4.1. The storage of chemical agents and ammunition requires the use of chemical hazard symbols. These symbols shall be used by themselves or in conjunction with fire symbols as appropriate.

C8.4.2. The chemical hazard symbols are illustrated in Figure C8.F2. Supplemental chemical hazard symbols are circular in shape, are yellow with black letters, and are illustrated in Figure C8.F3. Subsections C8.4.3. through C8.4.8., below, further describe these symbols, the hazards indicated by the symbols, and recommended protective clothing and equipment to be used for fighting fires. Protective clothing requirements for other than firefighting situations shall be determined by the DoD Components.

C8.4.3. When the chemical hazard symbol ordering the wearing of full protective clothing (symbol 1 of Figure C8.F2.) is colored with a red rim and figure, the symbol indicates the presence of highly toxic chemical agents which may cause death or serious damage to body functions. The following full protective clothing, identified as set 1 in Figure C8.F2. and column 3 of Table C8.T1. shall be used: M9 series protective gas mask, impermeable suit, impermeable

hood, impermeable boots, undergarments, coveralls, protective footwear, and impermeable gloves.

C8.4.4. When the chemical hazard symbol ordering the wearing of full protective clothing (symbol 1 of Figure C8.F2.) is colored with a yellow rim and figure, the symbol indicates the presence of harassing agents (riot control agents and smokes). The following protective clothing, identified as set 2 in Figure C8.F2. and column 4 of Table C8.T1., shall be used: M9 or M17 series protective gas masks or self-contained breathing apparatus (SCBA), permeable coveralls, and protective gloves.

C8.4.5. When the chemical hazard symbol ordering the wearing of full protective clothing (symbol 1 of Figure C8.F2.) is colored with a white rim and figure, the symbol indicates the presence of WP and other spontaneously combustible material. The following protective clothing, identified as set 3 in Figure C8.F2. and column 5 of Table C8.T1., shall be used: flame-resistant coveralls, flame-resistant gloves, M9 or M17 series protective gas masks or SCBA.

C8.4.6. The chemical hazard symbol ordering the wearing of breathing apparatus (symbol 2 of Figure C8.F2.) indicates the presence of incendiary and readily flammable chemical agents that present an intense radiant heat hazard. Protective masks shall be used to prevent inhalation of smoke from burning incendiary mixtures.

C8.4.7. Firefighting personnel equipped with normal heat-resistant clothing (bunker suit) and gas mask or SCBA do not require the protective clothing identified as sets 2 and 3 when fighting fires involving material in which sets 2 or 3 are specified in Table C8.T1.

C8.4.8. The chemical hazard symbol warning against applying water (symbol 3 of Figure C8.F2) indicates a dangerous reaction will occur if water is used in an attempt to extinguish fire.

C8.4.9. The chemical hazard symbol prohibiting the use of water in fire-fighting may be placed together with any one of the other symbols if required.

C8.4.10. The supplemental chemical hazard symbols described in Figure C8.F3. shall be used with other symbols as required to identify chemical agents having special chemical hazards.

C8.4.11. The chemical agents most used in ammunition, the compatibility groups of that ammunition, and the chemical hazard symbols required in storage are specified in Table C8.T1.

C8.5. **FIREFIGHTING MEASURES**

C8.5.1. Firefighters of ammunition and explosives fires shall have a thorough knowledge of the specific reactions of ammunition and explosives exposed to the heat or to the fire itself. The firefighting forces and other essential personnel shall be briefed before approaching the scene of the fire. They shall be informed of the known hazards and conditions existing at the scene of the fire before proceeding to the location of the fire.

C8.5.2. Fire involving ammunition and explosives shall be fought according to the hazard classification, fire division, the stage of the fire, and the procedures specified by the DoD Component concerned. Special firefighting instructions addressing ammunition hazards shall be developed according to the needs of the DoD Components.

C8.5.3. All fires starting in the vicinity of ammunition or explosives shall be reported and shall be fought immediately with all available means and without awaiting specific instructions. However, if the fire involves explosive material or is supplying heat to it, or if the fire is so large that it cannot be extinguished with the equipment at hand, the personnel involved shall evacuate and seek safety.

C8.5.4. Emergency withdrawal distances for nonessential personnel are intended for application in emergency situations only and are not to be used for facility siting. Emergency withdrawal distances depend on fire involvement and on whether or not the hazard classification, fire division and quantity of explosives are known. The withdrawal distance for essential personnel at accidents shall be determined by emergency authorities on site. Emergency authorities shall determine who are essential personnel.

C8.5.5. If a fire involves explosives or involvement is imminent, then the initial withdrawal distance applied shall be at least the inhabited building distance while the appropriate emergency withdrawal distance for nonessential personnel is being determined. When emergency authorities determine that the fire is or may become uncontrollable and may result in deflagration and/or detonation of nearby ammunition or explosive material, all nonessential personnel shall be withdrawn to the appropriate emergency withdrawal distance listed in Table C8.T2. If fire is not affecting explosives or involvement is not imminent, then emergency authorities shall determine the withdrawal distance based on the situation at hand.

C8.5.6. Structures or protected locations offering equivalent protection for the distances listed in Table C8.T2 may be used in lieu of relocating personnel from the structure and/or location to the specified emergency withdrawal distance.

C8.5.7. Commanders will develop evacuation plans for their installations that reference the appropriate withdrawal distances as part of the disaster response plan. The Commander is responsible for alerting civilian authorities of any imminent explosive accident on the installation that may affect the local community and for providing these authorities with the appropriate emergency withdrawal distances.

C8.5.8. Ammunition containing both explosives and chemical agents (see Table C8.T1.) requires special attention and precautions in firefighting. Fires involving such ammunition shall be fought in accordance with their fire division characteristics, but responding personnel must also take into account the potential additional hazards and precautions discussed in Chapter 11 relating to the effects of the chemical agents involved.

C8.5.9. Entry to underground storage facilities following a fire or explosion requires special precautions. Monitoring for the presence of toxic fumes, oxygen depleted atmospheres and structural damage shall be performed during initial entry following an accident.

Commanders will develop written procedures that define actions to be taken in such emergency situations.

*C8.6. **EMERGENCY PLANNING***

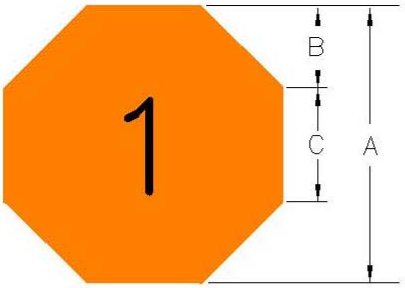
Installations or responsible activities shall develop standard operating procedures (SOPs) or plans designed to provide safety, security, and environmental protection. Plans shall be coordinated with the applicable Federal, State, and local emergency response authorities (e.g., law enforcement, fire departments, and hospitals, etc.) and any established Local Emergency Planning Committees (LEPC). At a minimum, those SOPs or plans shall include the following:

C8.6.1. Specific sections and guidance that address emergency preparedness, contingency planning, and security. For security, those SOPs or plans shall limit access to trained and authorized personnel.

C8.6.2. Procedures that minimize the possibility of an unpermitted or uncontrolled detonation, release, discharge, or migration of military munitions or explosives out of any storage unit when such release, discharge, or migration may endanger human health or the environment.

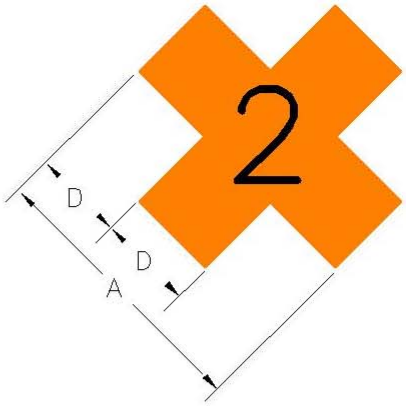
C8.6.3. Provisions for prompt notification to emergency response and environmental agencies and the potentially affected public for an actual or potential detonation or uncontrolled release, discharge, or migration (that may endanger human health or the environment).

C8.6.4. Provisions for complying with Sections 301-312 of the "Emergency Planning Community Right-To-Know Act (EPCRA)" (reference (o)), and DOD or Component implementing policies.



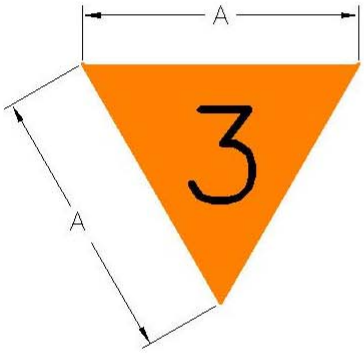
Fire Division 1 or 5

24-inch: NSN 7690-01-082-0290
12-inch: NSN 7690-01-081-9581



Fire Division 2 or 6

24-inch: NSN 7690-01-082-0289
12-inch: NSN 7690-01-087-7340



Fire Division 3

24-inch: NSN 7690-01-081-9583
12-inch: NSN 7690-01-081-9582

Fire Division 4

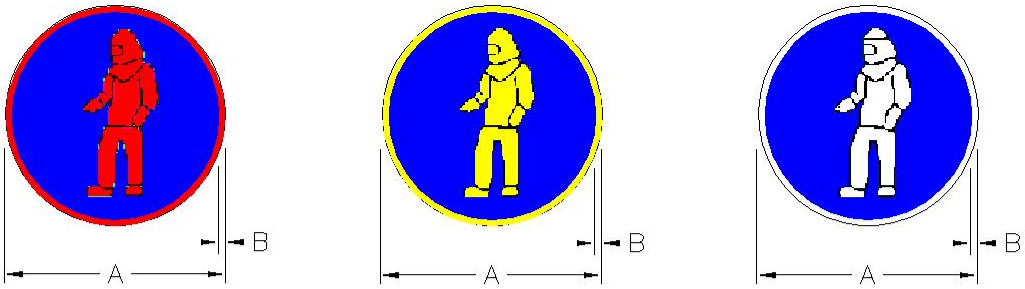
24-inch: NSN 7690-01-082-6709
12-inch: NSN 7690-01-081-9584

Dimensions	Large Symbol		Small Symbol	
	inches	metric (mm)	inches	metric (mm)
A	24	610	12	305
B	7	178	3.5	89
C	10	254	5	127
D	8	203	4	102
Letters (height)	10	254	5	127
Letters (thickness)	2	51	1	25

COLORS (per Federal Standard 595A or GSA Catalog):

Background: Orange #12246
Letters: Black #17038

Figure C8.F1. Fire Division Symbols

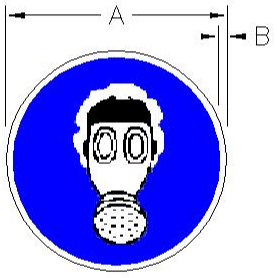


Symbol 1. Wear full protective clothing.
Background is blue, and figure and rim are as follows:

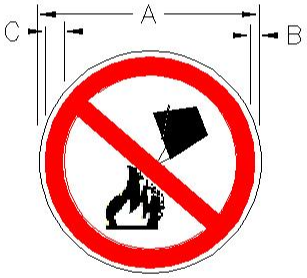
Red for Set 1 Protective Clothing:
24-inch: NSN 7690-01-081-9586
12-inch: NSN 7690-01-081-9585

Yellow for Set 2 Protective Clothing:
24-inch: NSN 7690-01-081-9587
12-inch: Not available

White for Set 3 Protective Clothing:
24-inch: NSN 7690-01-083-6272
12-inch: NSN 7690-01-081-9588



Symbol 2. Wear breathing apparatus.
Background is blue.
Figure and rim are white.
24-inch: NSN 7690-01-081-9589
12-inch: NSN 7690-01-082-0291



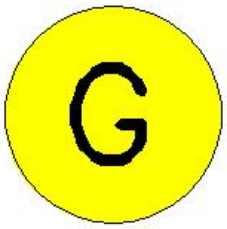
Symbol 3. Apply no water.
Background is white.
Circle and Diagonal are red.
Figures are in black.
24-inch: NSN 7690-01-082-2254
12-inch: NSN 7690-01-082-0292

Dimensions	Large Symbol		Small Symbol	
	inches	metric (mm)	inches	metric (mm)
A	24	610	12	305
B	.5	13	.25	6
C	2	51	1	25

COLORS (per Federal Standard 595A or GSA Catalog):

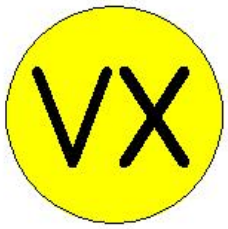
Red:	#11105	White:	#17875
Blue:	#15102	Black:	#17038
Yellow:	#13538		

Figure C8.F2. Chemical Hazard Symbols



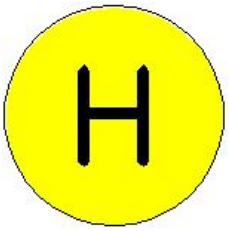
G-Type Nerve Agents

24-inch: NSN 7690-01-082-5418
12-inch: NSN 7690-01-081-7481



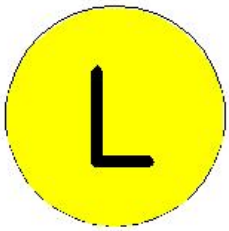
VX Nerve Agents

24-inch: NSN 7690-01-081-7483
12-inch: NSN 7690-01-081-7482



H-Type Mustard Agents

24-inch: NSN 7690-01-082-6713
12-inch: NSN 7690-01-083-1663



Lewisite

24-inch: NSN 7690-01-082-6715
12-inch: NSN 7690-01-082-6714

COLORS (per Federal Standard 595A or GSA Catalog):

Background: Yellow (#13538)

Letters: Black (#17038), as follows:

12 inches (305 mm) high and 2 inches (51 mm) thick on a 24-inch (610 mm) diameter circle.

6 inches (152 mm) high and 1 inch (25 mm) thick on a 12-inch (305 mm) diameter circle.

Figure C8.F3. Supplemental Chemical Hazard Symbols

Table C8.T1. Compatibility Group and Chemical Hazard Symbols Required for Storage of Chemical Ammunition and Substances

Chemical Ammunition and Substances	Compatibility Group[2]	Full Protective Clothing			Breathing Apparatus	Apply No Water
		Set 1	Set 2	Set 3		
1	2	3	4	5	6	7
Toxic Agents[1]	K	X				
Tear Gas, O-Chlorobenzol	G		X			
Smoke, Titanium Tetrachloride (FM)	G		X			
Smoke, Sulpher trioxide-chlorosulphonic acid solution (FS)	G		X			
Smoke, Aluminum-zinc oxide-hexachloroethane (HC)	G				X	X
White Phosphorous (WP)	H			X		
White Phosphorous plasticized (PWP)	H			X		
Thermite or Thermate (TH)	G				X	X
Pyrotechnic Material (PT)	G				X	X
Calcium Phosphide	L				X	X
Signaling Smokes	G				X	
Isobutyl methacrylate with oil (IM)	J				X	
Napalm (NP)	J			X	X	X
Triethylaluminim (TEA)(TPA)	L			X		X

Notes:

1. Toxic Agents without explosives components that normally would be assigned to Hazard Division 6.1 may be stored as compatibility group K

2. See Chapter 3.

(Changed as per 316th Board Meeting)

Table C8.T2. Emergency Withdrawal Distances for Non-essential Personnel

Hazard Division	Unknown Quantity	Known Quantity
Unknown, located in facility, truck and or tractor trailer	Approximately ¾ mile (4,000 ft)	4,000 ft
Unknown, located in railcar	Approximately 1 mile (5,000 ft)	5,000 ft
1.1 (Explosive A) and 1.5 (See note 1)	Same as unknown facility, truck trailer or railcar as appropriate	For transportation, use 2,500 ft minimum distance for 500 lb and below. Above 500 lb, for rail cars use 5,000 ft minimum distance; otherwise use 4,000 ft minimum distance. Use 4,000 ft minimum distance for bombs and projectiles with caliber 5 inch or greater. For facilities, use 2,500 ft minimum distance for 15,000 lb and below. Use 4,000 ft minimum distance for net explosive weights above 15,000 lb and less than or equal to 50,000 lb. Above 50,000 lb, use d (distance) = 105 $W^{1/3.}$
1.2 (1.2.1, 1.2.2, and 1.2.3) (Explosive A) and 1.6 (see Note 1)	2,500 ft	2,500 ft
1.3 (Explosive B) (See note 2)	600 ft	Twice the inhabited building distance (Table C9.T10.) with a 600 ft minimum range.
1.4 (Explosive C)	300 ft	300 ft

Notes:

1. For Hazard Division 1.1 and 1.2 items, if known, the maximum range fragments and debris will be thrown (including the interaction effects of stacks of items, but excluding lugs, strongbacks, and/or nose and tail plates) may be used to replace the minimum range.

2. For accidents involving propulsion units, it is not required to specify emergency withdrawal distances based upon the potential flight ranges of these items.

(Approved changes 13 October 2000)

C9. CHAPTER 9 QUANTITY-DISTANCE

C9.1. GENERAL

The damage or injury potential of explosions is normally determined by the prevailing distance between the PES and the ES; the ability of the PES to suppress blast overpressure, primary and secondary fragments, and debris; and the ability of the ES to resist explosion effects. This Chapter sets minimum standards for separating a PES from an ES that take into account anticipated explosion effects suppression and resistance. Q-D relationships are established for related and unrelated PESs and explosives and nonexplosives ESs.

C9.2. ESTABLISHMENT OF QUANTITY OF EXPLOSIVES AND DISTANCES

(Approved changes at 321st Board Meeting)

*C9.2.1. **Quantity of Explosives.** The total quantity of explosives in a facility is calculated as shown below. Where the DDESB has approved an HE equivalence for a propellant and/or pyrotechnic, then this HE equivalence may be used for determining NEW. In such cases, the sum of the HE plus the HE equivalence of the propellant and/or pyrotechnic will be the applicable NEW. The JHCS provides explosive weights for all DoD Hazard Classified ammunition and explosives*

C9.2.1.1. Mass-explosion (HD 1.1). The NEW is the total weight of all HE plus the total weight of all propellant in the HD 1.1 items.

C9.2.1.2. Non-mass explosion, fragment producing (HD 1.2).

C9.2.1.2.1. HD 1.2.1. The NEW is the total weight of all HE plus the total weight of propellant in all HD 1.2.1 items. In certain situations, the maximum credible event (MCE), as outlined in C9.3.2.5, will be used as the basis for determining applicable Q-D.

C9.2.1.2.2. HD 1.2.2. The NEW is the total weight of all HE plus the total weight of propellant in all HD 1.2.2 items.

C9.2.1.2.3. HD 1.2.3. (Unit Risk HD 1.2). The NEW is the total weight Of all HE plus the total weight of propellant in all HD 1.2.3 items. This material is treated as HD 1.3, however, a minimum IBD will apply, as outlined in C9.3.2.12.

C9.2.1.3. Mass fire, minor blast, or fragment (HD 1.3). The NEW is the total weight of all HE, propellant, and pyrotechnics in all HD 1.3 items.

C9.2.1.4. Moderate fire, no blast, or fragment (HD 1.4). The NEW is the total weight of all HD, propellant, and pyrotechnics in all HD 1.4 items.

C9.2.1.5. Explosive substance, very insensitive (with mass explosion hazard) (HD 1.5). The NEW is the total weight of all HE plus the total weight of propellant in all HD 1.5 items.

C9.2.1.6. Explosive article, extremely insensitive (HD 1.6). The NEW is the total weight of EIDS in all HD 1.6 items. However, the weight of EIDS in a single HD 1.6 will also be considered, as specified in C9.T12, for determining Q-D.

C9.2.1.7. Exclusions. Munitions' fillers that do not contribute to explosive effects (e.g. colored and HC smoke, dyes, irritants, white phosphorus (WP), plasticized white phosphorus (PWP), and pyrophoric agent TPA) are excluded when determining NEW.

C9.2.1.8. If DDESB-approved buffer configurations are provided, the NEW is the explosives weight of the largest stack plus, if applicable, the explosives weight of the buffer material, excluding the NEW of HD 1.4.

C9.2.1.9. Determining the Explosive Weight for Mixed HDs.

C9.2.1.9.1 General.

C9.2.1.9.1.1. The presence of HD 1.4 does not affect the NEW of mixed HD.

C9.2.1.9.1.2. When HD 1.1 is mixed with any other HD, treat the mixture as HD 1.1, except as noted in C9.2.1.9.2.

C9.2.1.9.1.3. HD 1.5 is always treated as HD 1.1.

C9.2.1.9.2. HD 1.1 with HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3). Use whichever of the following generates the largest QD: a) sum the NEW for HD 1.1 and NEW for HD 1.2 and treat the mixture as HD 1.1, or b) the NEW of the mixture is the NEW of the HD 1.2 subdivision requiring the largest Q-D.

C9.2.1.9.3 HD 1.1 with HD 1.3. Sum the New for HD 1.1 and the NEW for HD 1.3 and treat the mixture as HD 1.1.

C9.2.1.9.4. HD 1.1 with HD 1.6. Sum the NEW for HD 1.1 and the NEW for HD 1.6 and treat the mixture as HD 1.1.

C9.2.1.9.5. HD 1.2.1 with HD 1.2.2. The New for the mixture is the NEW of the sub-division requiring the largest Q-D.

C9.2.1.9.6. HD 1.2.1 with HD 1.2.3. The NEW for the mixture is the NEW of the sub-division requiring the largest Q-D.

C9.2.1.9.7. HD 1.2.2 with HD 1.2.3. The NEW for the mixture is the

NEW of the sub-division requiring the largest Q-D.

C9.2.1.9.8 HD 1.2.1 with HD 1.2.2 with HD 1.2.3. The NEW for the mixture is the NEW of the sub-division requiring the largest Q-D.

C9.2.1.9.9. HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3) with HD 1.3. The NEW for the mixture is the NEW of the HD requiring the largest Q-D.

C9.2.1.9.10. HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3) with HD 1.6. Treat the HD 1.6 as HD 1.2.3 and determine NEW in accordance with C9.2.1.9.6 through C9.2.1.9.8 above, as applicable.

C9.2.1.9.11. HD 1.3 with HD 1.6. Sum the NEW for the HD 1.6 and the NEW for HD 1.3 and treat the mixture as HD 1.3.

C9.2.2. **Q-D Computations and Determinations**

C9.2.2.1. Throughout these standards, NEW is used to calculate distance by means of formula of the type $D = K \bullet W^{1/3}$, when D is the distance in feet, K is a factor depending upon the risk assumed or permitted, and W is the NEW in pounds. When metric units are used, the symbol Q denotes NEQ in kilograms. In the formula $D = K \bullet Q^{1/3}$, the distance D is expressed in meters. Thus, the respective units of K are $ft/lb^{1/3}$ and $m/kg^{1/3}$ in the two systems. The value of K in English units is approximately 2.5 times its value in metric units. For example, if $D(m) = 6 \bullet Q^{1/3}$, then $D(ft) = 15 \bullet W^{1/3}$. Distance requirements determined by the formula with English units are sometimes expressed by the value of K, using the terminology K9, K11, K18, to mean K = 9, K = 11, and K = 18.

(Changed after the 319th Board Meeting)

C9.2.2.2. The quantity of explosives in a magazine, operating building, or other explosives site shall be considered the net explosive weight of the controlling class of explosives contained therein (the class requiring the greatest separation). For the High Performance Magazine the net explosive weight, NEW, for determining separation distances, is based on the maximum credible event, MCE. The MCE is the sum of the contents of an individual open cell and the loading dock, rather than the aggregate NEW for the entire magazine.

C9.2.2.2.1. Extensive tests and analytical work have proven that when two or more stacks of equal amounts of mass-detonating explosives detonate within short time intervals (the time in milliseconds is less than 4.0 times the cube root of the explosive weight of any one stack in pounds for lateral target positions and less than 5.6 times the cube root of the explosive weight in pounds for axial target position) the blast waves will coalesce. The combined shock wave, after coalescence, will be that of a single detonation of a charge equal to the summation of the several stacks. The actual separation time between successive detonations is influenced by the spatial separation of explosives, geometry, and distribution, the character of the dividing wall or other barrier between, and the sensitivity of the explosives.

C9.2.2.2.2. When it is considered advantageous for Q-D computations to subdivide a total quantity of mass-detonating explosives into smaller units, it shall be ensured by construction of a suitable barrier or provision of adequate separation that there will be no propagation from one to another. Design of intervening barriers in accordance with the principles contained in TM 5-1300, AFM 88-22, NAVFAC P-397 (reference (g)) will satisfy this requirement. If this requirement is met, the explosive content of the subdivision requiring the greatest distance will govern. If this requirement is not met, Q-D computations must be based upon the summation of the mass-detonating explosives in all of the subdivisions.

C9.2.2.3. The quantity of explosives to be permitted in each of two or more locations shall be determined by considering each location as a potential explosion site. The quantity of explosives to be permitted in each of these locations shall be the amount permitted by the distance specified in the appropriate Q-D tables considering each as a potential target site in turn, except for service magazines (see paragraphs C2.4.1.9. and C2.4.2.8., Chapter 2).

C9.2.2.4. Interpolation and extrapolation of Q-D specified in Table C9.T1. shall be in accordance with footnotes to the table, except that minimum distances for specific weapons listed in Table C9.T2. may apply. Interpolation and extrapolation of Tables C9.T3., C9.T4. and C9.T5. shall be accomplished by use of columnar formulae cited in the tables.

C9.2.2.5. It is impractical to specify Q-D separations allowing for the designed flight range of propulsive units (rockets, missile motors, and catapults) that properly belong in Hazard Division 1.1, 1.2, or 1.3. Therefore, maximum designed flight ranges for units in a propulsive state shall be disregarded. The distance required to protect from fragments in credible accident situations, however, shall be established in accordance with the principles in section C2.5., Chapter 2.

C9.2.2.6. Measurements of distance for determining the maximum allowable quantity of explosives shall be made from the nearest wall of the structure containing explosives, or exterior of the nearest wall of the controlling subdivision when the structure is subdivided so that mass detonation between subdivisions will not occur, to the nearest part of an exposed structure or site. Separation distances are measured along straight lines. For large intervening topographical features such as hills, measure over or around the feature, whichever is the shorter. For golf courses, measure to the nearest edge of the tee or green and the centerline of fairways.

C9.2.2.7. When railroad cars or motor vehicles containing ammunition and explosives are not separated from operating buildings, magazines, or open storage sites containing ammunition and explosives in such a manner as to prevent their mass detonation, the total quantity of explosives (see subsection C9.2.1., above) in such locations, railcars, and motor vehicles shall be considered as a unit and the separation distance measured from the nearest outside wall of the building, railcar, vehicle, or edge of open stack, as appropriate, to a target. If the explosives are separated into smaller units so that mass detonation of the explosives in the railcars and motor vehicles and inside the units will not occur, the separation distance shall be measured from the nearest controlling explosives unit, railcar, or vehicle to a target.

(Added after 319th Board Meeting)

C9.2.2.8. When computing safe separation distances for the High Performance Magazine, the net explosive weight used in the calculations is the maximum credible event, MCE, that could occur during ammunition transfer. The MCE is determined by adding the NEW in an individual cell to the NEW at the loading dock. Safe separation distances are calculated using the MCE of the High Performance Magazine. The MCE for the HPM shall not exceed 60,000 pounds.

C9.3. **HAZARD DIVISION Q-D TABLES**

C9.3.1. **Hazard Division 1.1**

C9.3.1.1. **Inhabited Building and Public Traffic Route Distances.** Separation distances required from ECM and other types of PESs to inhabited buildings and public traffic routes are listed for various quantities of Hazard Division 1.1 in Table C9.T1. Specified separations from ECM take into account reductions in blast overpressure attributable to the earth cover of the magazines. Permissible exposures at these distances are listed in subsections C2.4.3., C2.4.4., C2.4.5. and C2.4.6., Chapter 2.

(Approved changes at 321st Board Meeting)

*C9.3.1.2. **Intraline Distance.** Separation distances required between explosives and nonexplosives buildings and sites within an explosives operating line are listed for various quantities of Hazard Division 1.1 in Table C9.T3. Provisions of subsection C9.2.2., above, shall be used in applying this table except that the distance required between an explosives operating building and its service magazines is determined by the quantity of explosives in the service magazines irrespective of the quantity in the operating building. Permissible exposures at intraline distances are listed in subsections C2.4.1. (barricaded intraline distance) and C2.4.2. (unbarricaded intraline distance) of Chapter 2. In order to apply barricaded intraline distance, barricades must comply with C5.3.*

C9.3.1.2.1. Intraline Distance from ECM. Testing has shown some attenuation of the airblast overpressure occurs out the sides and rear of ECM and a slight increase out the front of an ECM, relative to the unconfined surface burst. The equivalent $9W^{1/3}$ (12 psi) barricaded intraline distance and $18W^{1/3}$ (3.5 psi) unbarricaded intraline distance from ECM, accounting for this attenuation, are given in C9.T4.

C.9.3.1.2.2. Barricaded Intraline Distance form ECM. Paragraph C9.3.1.3.5 provides criteria for the application of barricaded intraline distance from ECM.

C9.3.1.2.3. Intraline Distance from HP Magazines. Test results show that the earth-bermed HP attenuates pressures relative to the unconfined surface burst configuration. The attenuation is similar to that shown for an ECM in C9.3.1.2.1. The values shown in Table C9.T4 for the front exposure also apply to the front of the HPM. The values shown in Table C9.T4 for the side exposure also apply to the side and rear exposures of the HPM. The

definition of "front" for ECM (see C9.3.1.3.1) also applies to the HPM. (Added after 319th Board Meeting)

C9.3.1.3. Intermagazine Distances. Magazines for Hazard Division 1.1 shall be separated on from another in accordance with Table C9.T5. Magazine orientation aspects of Table C9.T5, Part A, involve the following considerations:

C9.3.1.3.1. When ECM containing Hazard Division 1.1 ammunition are sited as that any one is in the forward sector of another, the two must be separated by distances greater than the minimum permitted for side-to-side orientations. The forward sector, or "front," of an ECM is that area 60 degrees either side of the magazine centerline (120° combined angle) with the vertex of the angle placed so that the sides of the angle pass through the intersection of the headwall and sidewalls. The greater distances are required primarily for the protection of door and headwall structures against blast from a PES forward of the exposed magazine, and to a lesser extent due to the directionality of effects from the source. The rear sector, or "rear," of an ECM is that area 45 degrees either side of the magazine centerline (90° combined angle) with the vertex of the angle placed so that the sides of the angle pass through the intersection of the rear and side walls. Figure C9.F1.(g) illustrates the front (120°), side, and rear (90°) sectors of an ECM. When a blast wave is reflected from a surface at other than grazing incidence (side-on-orientation), the overpressure may be increased substantially over the free-field value. High reflected pressure and impulse can damage doors and headwalls and propel the debris into the ECM so that explosion is communicated by impact of such debris upon the contents.

C9.3.1.3.2. Examples of siting rules relative to magazine orientations (illustrated in Figure C9.F1) follow:

C9.3.1.3.2.1. See Figure C9F1. (a) and (b). Site A as a side-to-side ES. Site B as side-to-side ES. Orientations are to be thought of as from the PES to the ES.

C9.3.1.3.2.2. See Figure (C9.F1. (c). Site A as a side-to-front ES. Site B as a front-to-side ES.

C9.3.1.3.2.3. See Figure C9.F1. (d). Site each magazine as a front-to-front ES. Site C as a barricaded ES. Site A and B as unbarricaded ESs.

C9.3.1.3.2.4. Two additional ECM orientations warrant analysis, namely:

C9.3.1.3.2.4.1. See Figure C9.F1. (e). Site A as a side-to-front ES. Site B as a front-to-side ES.

C9.3.1.3.2.4.2. See Figure C9.F1(f). Site A as a side-to-front ES. Site B as a front-to-side ES.

C9.3.1.3.3. Barricaded Intermagazine Distance from ECM. Paragraph C9.3.1.3.5 provides criteria for the application of barricaded intermagazine distance from ECM.

C9.3.1.3.4. Other factors limiting an ECM storage area are:

C9.3.1.3.4.1. Quantities above 500.000 lbs. NEW of Hazard Division 1.1 are not authorized in any one storage location, except for liquid propellants.

C9.3.1.3.4.2. The distances given in Table C9.T5, Part B, for 100 lbs. NEW of Hazard Division 1.1 constitute the minimum required magazine spacing.

C9.3.1.3.5. Application of Barricaded Intraline Distance and Barricaded Intermagazine Distance from an ECM. C9.F1. (g) illustrates the intermagazine relationships that can exist between an ECM and and aboveground magazine and the intraline relationships that can exist between an ECM and a facility permitted to be at intraline distance or barricaded intraline distance from an ECM, when each contain HD 1.1 ammunition and explosives. Permissible intraline distance and barricaded intraline distance exposures are provided in paragraphs C2.4.1 and C2.4.2. Siting criteria for aboveground magazines are provided in Table C9.T5, Part A. The following criteria will apply to use of barricaded intermagazine distance for aboveground magazine and for use of barricaded intraline distance from an ECM:

C9.3.1.3.5.1. Front (120°) Sector of an ECM. Application of barricaded intraline distance or barricaded intermagazine distance, as applicable, from an ECM to an ES located within the ECM's 120° front sector requires that an intervening barricade meeting construction criteria of C5.3 be located between the ECM and the ES. If the intervening barricade does not meet these construction criteria, then unbarricaded intermagazine distance or intraline distance, as applicable, must be used for siting purposes.

C9.3.1.3.5.2. Side and Rear (90°) Sectors of an ECM. If an ECM's earth cover meets construction criteria of C5.3, it qualifies as a barricade, and use of barricaded intraline distance or barricaded intermagazine distance, as applicable, from the sides or rear of the ECM is permissible. Failure of the ECM's earth cover to meet these criteria will require use of unbarricaded intraline distance or unbarricaded intermagazine distance, as applicable, for siting purposes.

C9.3.1.3.6. Standards given in subparagraphs C9.3.1.3.1. through C9.3.1.3.5., above apply only to the storage of Hazard Division 1.1 ammunition and explosives. Existing ECM, regardless of orientation, meeting the construction and barricading requirements of Chapter 5 (and sited one from another for a minimum of 100 pounds NEW of Hazard Division 1.1), may be used to their physical capacity for the storage of Hazard Divisions 1.2, 1.3, and 1.4 provided distances to other exposures comply with applicable Q-D tables.

(Changed at 319th Board Meeting)

Table C9.T1. Hazard Division 1.1 Inhabited Building and Public Traffic Route Distances (See Notes)

Net Explosive Weight (NEW) lbs	Distance in Feet to Inhabited Building From:				Distance in Feet to Public Traffic Route From:			
	Earth-Covered Magazine			Other PES	Earth-Covered Magazine			Other PES
	Front	Side	Rear		Front	Side	Rear	
Col 1	Col 2[1,8,9]	Col 3[1,8]	Col 4[2,8]	Col 5[3]	Col 6[4,8,10]	Col 7[5,8]	Col 8[6,8]	Col 9[7]
1	500	250	250	See note 3	300	150	150	See note 7
2	500	250	250		300	150	150	
5	500	250	250		300	150	150	
10	500	250	250		300	150	150	
20	500	250	250		300	150	150	
30	500	250	250		300	150	150	
40	500	250	250		300	150	150	
50	500	250	250		300	150	150	
100	500	250	250		300	150	150	
150	500	250	250		300	150	150	
200	700	250	250		420	150	150	
250	700	250	250		420	150	150	
300	700	250	250		420	150	150	
350	700	250	250		420	150	150	
400	700	250	250		420	150	150	
450	700	250	250	▼	420	150	150	▼
500	1,250	1,250	1,250	1,250	750	750	750	750
600	1,250	1,250	1,250	1,250	750	750	750	750
700	1,250	1,250	1,250	1,250	750	750	750	750
800	1,250	1,250	1,250	1,250	750	750	750	750
900	1,250	1,250	1,250	1,250	750	750	750	750
1,000	1,250	1,250	1,250	1,250	750	750	750	750
1,500	1,250	1,250	1,250	1,250	750	750	750	750
2,000	1,250	1,250	1,250	1,250	750	750	750	750
3,000	1,250	1,250	1,250	1,250	750	750	750	750
4,000	1,250	1,250	1,250	1,250	750	750	750	750
5,000	1,250	1,250	1,250	1,250	750	750	750	750
6,000	1,250	1,250	1,250	1,250	750	750	750	750
7,000	1,250	1,250	1,250	1,250	750	750	750	750
8,000	1,250	1,250	1,250	1,250	750	750	750	750
9,000	1,250	1,250	1,250	1,250	750	750	750	750
10,000	1,250	1,250	1,250	1,250	750	750	750	750
15,000	1,250	1,250	1,250	1,250	750	750	750	750
20,000	1,250	1,250	1,250	1,250	750	750	750	750
25,000	1,250	1,250	1,250	1,250	750	750	750	750
30,000	1,250	1,250	1,250	1,250	750	750	750	750
35,000	1,250	1,250	1,250	1,310	750	750	750	785
40,000	1,250	1,250	1,250	1,370	750	750	750	820
45,000	1,250	1,250	1,250	1,425	750	750	750	855
50,000	1,290	1,290	1,250	1,475	775	775	750	995
55,000	1,330	1,330	1,250	1,520	800	800	750	910
60,000	1,370	1,370	1,250	1,565	820	820	750	940
65,000	1,405	1,405	1,250	1,610	845	845	750	965
70,000	1,440	1,440	1,250	1,650	865	865	750	990

Table C9.T1. Hazard Division 1.1 Inhabited Building and Public Traffic Route Distances (See Notes)

Net Explosive Weight (NEW) lbs	Distance in Feet to Inhabited Building From:				Distance in Feet to Public Traffic Route From:			
	Earth-Covered Magazine			Other PES	Earth-Covered Magazine			Other PES
	Front	Side	Rear		Front	Side	Rear	
Col 1	Col 2[1,8,9]	Col 3[1,8]	Col 4[2,8]	Col 5[3]	Col 6[4,8,10]	Col 7[5,8]	Col 8[6,8]	Col 9[7]
75,000	1,475	1,475	1,250	1,685	885	885	750	1,010
80,000	1,510	1,510	1,250	1,725	905	905	750	1,035
85,000	1,540	1,540	1,250	1,760	925	925	750	1,055
90,000	1,570	1,570	1,250	1,795	940	940	750	1,075
95,000	1,595	1,595	1,250	1,825	960	960	750	1,095
100,000	1,625	1,625	1,250	1,855	975	975	750	1,115
110,000	1,740	1,740	1,290	1,960	1,045	1,045	770	1,175
120,000	1,855	1,855	1,415	2,065	1,110	1,110	850	1,240
125,000	1,910	1,910	1,480	2,115	1,165	1,165	890	1,270
130,000	1,965	1,965	1,545	2,165	1,180	1,180	925	1,300
140,000	2,070	2,070	1,675	2,255	1,245	1,245	1,005	1,355
150,000	2,175	2,175	1,805	2,350	1,305	1,305	1,085	1,410
160,000	2,280	2,280	1,935	2,435	1,370	1,370	1,160	1,460
170,000	2,385	2,385	2,070	2,520	1,430	1,430	1,240	1,515
175,000	2,435	2,435	2,135	2,565	1,460	1,460	1,280	1,540
180,000	2,485	2,485	2,200	2,605	1,490	1,490	1,320	1,565
190,000	2,585	2,585	2,335	2,690	1,550	1,550	1,400	1,615
200,000	2,680	2,680	2,470	2,770	1,610	1,610	1,480	1,660
225,000	2,920	2,920	2,810	2,965	1,750	1,750	1,685	1,780
250,000	3,150	3,150	3,150	3,150	1,890	1,890	1,890	1,890
275,000	3,250	3,250	3,250	3,250	1,950	1,950	1,950	1,950
300,000	3,345	3,345	3,345	3,345	2,005	2,005	2,005	2,005
325,000	3,440	3,440	3,440	3,440	2,065	2,065	2,065	2,065
350,000	3,525	3,525	3,525	3,525	2,115	2,115	2,115	2,115
375,000	3,605	3,605	3,605	3,605	2,165	2,165	2,165	2,165
400,000	3,685	3,685	3,685	3,685	2,210	2,210	2,210	2,210
425,000	3,760	3,760	3,760	3,760	2,250	2,250	2,250	2,250
450,000	3,830	3,830	3,830	3,830	2,300	2,300	2,300	2,300
475,000	3,900	3,900	3,900	3,900	2,340	2,340	2,340	2,340
500,000	3,970	3,970	3,970	3,970	2,380	2,380	2,380	2,380

Notes for Table C9.T1.:

1. Bases for Columns 2 and 3 distances:

   1-45,000 lbs - debris hazard - lesser distances permitted if proved sufficient to limit hazardous debris to 1/600 ft^2.
   Formula $d = 35W^{1/3}$ (blast overpressure) may be used if fragments and debris are absent.

   45,000-100,000 lbs - blast overpressure hazard. Computed by formula $d = 35W^{1/3}$.
   100,000-250,000 lbs - blast overpressure hazard. Computed by formula $d = 0.3955W^{0.7227}$
   250,000 lbs and above - blast overpressure hazard. Computed by formula $d = 50W^{1/3}$.

2. Bases for Column 4 distances:

   100,000 lbs - debris hazard - lesser distances permitted if proved sufficient to limit hazardous debris to 1/600 ft^2.
   Formula $d = 25W^{1/3}$ (blast overpressure) may be used if fragments and debris are absent.
   100,000-250,000 lbs - blast overpressure hazard. Computed by formula $d = 0.004125W^{1.0898}$.
   250,000 lbs and above - blast overpressure hazard. Computed by formula $d = 50W^{1/3}$.

(*Changed by correspondence July 5, 2000)*

3. Bases for Column 5 Distances:

(Changed by 322nd Board Meeting)

1-30,000 lbs- fragments and debris hazard. Lesser distances permitted by C2.5.2.3.1 of Chapter 2.

30,000-100,000 lbs - blast overpressure hazard. Computed by formula $d = 40W^{1/3}$.
100,000-250,000 lbs - blast overpressure hazard. Computed by formula $d = 2.42W^{0.577}$.
250,000 lbs and above - blast overpressure hazard. Computed by formula $d = 50W^{1/3}$.

4. Column 6 distances have the same hazard bases and are equal to 60 percent of Column 2 distances.

5. Column 7 distances have the same hazard bases and are equal to 60 percent of Column 3 distances.

6. Column 8 distances have the same hazard bases and are equal to 60 percent of Column 4 distances.

7 Column 9 distances have the same hazard bases and are equal to 60 percent of Column 5 distances.

8 Distances for NEWs between 30,000 and 250,000 lbs apply only for earth-covered magazines that are 26 ft. wide and 60 ft. long, or larger. For smaller earth-covered magazines, use other PES distances of Columns 5 or 9.

9 Column 2 Inhabited Building Distances apply to all directions from High Performance Magazines. The maximum credible event in the HPM is used as the NEW (Column 1). The limit on the design MCE in an HPM is 60,000 lbs.

10 Column 6 Public Traffic Route Distances apply to all directions from High Performance Magazines. The maximum credible event in the HPM is used as the NEW (Column 1). The limit on the design MCE in an HPM is 60,000 lbs.

(Changed by correspondence July 5, 2000)

Table C9.T2. Hazardous Fragment Distances for Open Stacks of Selected Hazard Division 1.1 Items[1]

Nomenclature [a]	Number of Units									
	1	2	3	4	5	6	7	8	9	10
Sparrow, AIM-7[b]	280	565	770	955	1120	1245				
Sidewinder, AIM-9	400	400	400	400	400	400	400	400	400	400[2]
Chaparral, MIM-72H	400	400	400	400	400	400	400	400	400	400[2]
Maverick, AGM 65 A/B/D	400	500	500							
Maverick, AGM 65 E/F/G	670	900[3]	1200[3]							
ASROC	500	500	500							
CBU-87*	800	800	910	945	965	982	1000	1020	1035	1055[4]
Improved Hawk	900	900	900	900	900	900	900	900	900	900[2]
Penguin*	500	500	500							
Projectile, 105 mm, M1[c]	340	355	525	660	725	775	810	845	870	890[4]
Projectile, 155 mm, M107	415	590	770	955	1035	1095	1145	1195	1235	
Projectile, 5"/54	300	375	475	570	680	790	860	925	1005	1085
Harpoon*	500	600[5]	600[5]	600[5]						
Tomahawk*	500	600[5]	600[5]	600[5]						
Bomb, 500-pound, MK 82	670									
Bomb, 1000-pound, MK 83	815									
Bomb, 2000-pound, MK 84	925									
Bomb, BLU-109	880									
Bomb, 750-pound, M117	690									
Torpedo, MK 46	500	500	500	500	500	500	500	500		
Torpedo, MK 48[d]	630	775	875	925						
Torpedo, MK 48 with shield[d,e]	500	500	550	600	635	670	700	725	755	780[4]

GENERAL COMMENTS:

a. *Items identified by an asterisk "*" include fragments from their shipping/storage container(s). However, the all of the fragment distances in this table may be applied to both packaged and unpackaged configurations.*

b. *Those items with WAU-17 warhead.*

c. *105-mm projectiles and 105-mm complete rounds not in standard storage and shipping containers are HD 1.1.*

d. *All MODS (includes ADCAP).*

(Approved change at 321st Board Meeting)

e. *Sandbag shield is required only during handling of torpedoes from motor vehicles. Sandbag shield requirement is equivalent to a minimum thickness of 2-feet of sand between the motor vehicle cab and the torpedoe(s). The sandbags must shield all parts of the motor vehicle cab from the torpedo warhead.. The barricade is not required during handling from boats, torpedo transporters, forklifts, or portable cranes.*

NOTES:

1. *See Paragraph C2.5.2.3. The hazardous fragment distance is defined as the distance at which the density of hazardous fragments reaches a value of 1 per 600 ft^2.*

2. *Ten units or more until the point is reached at which this distance is exceeded by the distance requirements of Table C9.T1*

3. *Use the distance shown only where there are less than 25 unrelated people exposed in any arc encompassing 45 degrees from 900 to 1250 feet from the PES.*

4. *More than 10 units may be involved before 1250 feet is exceeded. For distances involving more than 10 units consult the applicable Service guidance.*
5. *When handling more than one missile, the missiles must be transported and/or handled in a nose-to-tail configuration and in their launch capsule and/or shipping container; furthermore, they must be aligned and/or handled so that each group of two missiles is located outside of the warhead fragment beam spray region of the other two missiles.*

Table C9.T3. Hazard Division 1.1, Intraline Distances

Net Expl. Wt. (lb)	Distance in Feet Hazard Factor		Notes	Net Expl. Wt. (lb)	Distance in Feet Hazard Factor		Notes
	Bar k=9	Unbar k=18			Bar k=9	Unbar k=18	
50	33	66	1	70,000	371	742	
100	42	84		75,000	380	759	
200	53	105		80,000	388	776	
300	60	120		85,000	396	791	
400	66	133		90,000	403	807	
500	71	143		95,000	411	821	
600	76	152		100,000	418	835	
700	80	160		125,000	450	900	
800	84	167		150,000	478	956	
900	87	174		175,000	503	1,007	
1,000	90	180		200,000	526	1,053	
1,500	103	206		225,000	547	1,095	
2,000	113	227		250,000	567	1,134	
3,000	130	260		275,000	585	1,171	
4,000	143	286		300,000	602	1,205	
5,000	154	308		325,000	619	1,238	
6,000	164	327		350,000	634	1,269	
7,000	172	344		375,000	649	1,298	
8,000	180	360		400,000	663	1,326	
9,000	187	374		500,000	714	1,429	2
10,000	194	388		600,000	759	1,518	
15,000	222	444		700,000	799	1,598	
20,000	244	489		800,000	835	1,671	
25,000	263	526		900,000	869	1,738	
30,000	280	559		1,000,000	900	1,800	
35,000	294	589		1,500,000	1030	2,060	
40,000	308	616		2,000,000	1134	2,268	
45,000	320	640		2,500,000	1221	2,443	
50,000	332	663		3,000,000	1298	2,596	
55,000	342	685		3,500,000	1366	2,733	
60,000	352	705		4,000,000	1429	2,857	
65,000	362	724		5,000,000	1539	3,078	

Notes:

1. For less than 50 pounds, less distance may be used when structures, blast mats and the like can completely contain fragment and debris. This table is not applicable when blast, fragments and debris are completely confined, as in certain test firing barricades.

2. Quantities above 500,000 lbs NEW are authorized only for UN Class 1 (explosives) energetic liquids.

Table C9.T4. Hazard Division 1.1, Intraline Distances from Earth-Covered Magazines

NEW	Barricaded			Unbarricaded		
	Front[1]	Side[2]	Rear[3]	Front[4]	Side[5]	Rear[6]
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
50	37	26	22	66	59	44
70	41	29	25	74	66	49
100	46	32	28	84	74	56
150	53	37	32	96	85	64
200	58	41	35	105	94	70
300	67	47	40	120	107	80
500	79	56	48	143	127	95
700	89	62	53	160	142	107
1,000	100	70	60	180	160	120
1,500	114	80	69	206	183	137
2,000	126	88	76	227	202	151
3,000	144	101	87	260	231	173
5,000	171	120	103	308	274	205
7,000	191	134	115	344	306	230
10,000	215	151	129	388	345	259
15,000	247	173	148	444	395	296
20,000	271	190	163	489	434	326
30,000	311	218	186	559	497	373
50,000	368	258	221	663	589	442
70,000	412	288	247	742	659	495
100,000	464	325	278	835	743	557
150,000	531	372	319	956	850	653
200,000	585	409	351	1,053	936	746
300,000	669	469	402	1,205	1,071	937
500,000	716	714	714	1,429	1,429	1,429

NOTES FOR C9.T4.
NEW in lbs, d in ft)

1.	NEW $\leq$ 300,000 lbs	$d = 10*NEW^{1/3}$
	300,000 lbs < NEW < 500,000 lbs ------	$d = (13.659 – 1.6479e\text{-}05*NEW + 1.4358e\text{-}11* NEW^2)*NEW^{1/3}$
	d $\leq$ 669 ft	$NEW = d^3/1000$
	669 ft < d < 715 ft	$NEW = 1.50138e+08 - 6.73914e+05*d + 1002.9*d^2 - 0.4938*d^3$
2.	NEW $\leq$ 300,000 lbs	$d = 7*NEW^{1/3}$
	300,000 lbs < NEW $\leq$ 400,000 lbs	$d = (1.0848 + 1.986e\text{-}05*NEW)*NEW^{1/3}$
	NEW > 400,000 lbs	$d = 9*NEW^{1/3}$
	d $\leq$ 469 ft	$NEW = d^3/343$
	469 ft < d < 663 ft	$NEW = 57,424 + 515.89*d$
	d > 663 ft	$NEW = d^3/729$
3.	NEW $\leq$ 300,000 lbs	$d = 6*NEW^{1/3}$
	300,000 lbs < NEW < 400,000 lbs	$d = (-3.059 + 3.0228e\text{-}05*NEW)*NEW^{1/3}$
	NEW > 400,000 lbs	$d = 9*NEW^{1/3}$
	d $\leq$ 402 ft	$NEW = d^3/216$
	402 ft < d < 665 ft	$NEW = 148,160 + 379.7*d$
	d > 665 ft	$NEW = d^3/729$
4.	NEW < 500,000 lbs	$d = 18*NEW^{1/3}$
	d $\leq$ 1429 ft	$NEW = d^3/5,832$
5.	NEW $\leq$ 300,000 lbs	$d = 16*NEW^{1/3}$
	300,000 lbs < NEW $\leq$ 400,000 lbs	$d = (9.9683 + 2.0135e\text{-}05*NEW)*NEW^{1/3}$
	NEW > 400,000 lbs	$d = 18*NEW^{1/3}$
	d $\leq$ 1071 ft	$NEW = d^3/4,096$
	1071 ft < d < 1328ft	$NEW = -118,180 + 390.35*d$
	d > 1328 ft	$NEW = d^3/5,832$
6.	NEW $\leq$ 100,000 lbs	$d = 12*NEW^{1/3}$
	100,000 lbs < NEW $\leq$ 300,000 lbs	$d = (11.521 + 1.9918e\text{-}06*NEW + 2.0947e\text{-}11* NEW^2)* NEW^{1/3}$
	300,000 lbs < NEW $\leq$ 400,000 lbs	$d = (1.9389+ 4.0227e\text{-}05*NEW)* NEW^{1/3}$
	NEW > 400,000 lbs	$d = 18*NEW^{1/3}$
	d $\leq$ 557 ft	$NEW = d^3/1,728$
	557 ft < d < 938ft	$NEW = -193,080+526.83*d$
	938 ft < d < 1328ft	$NEW = 60,778 + 255.83*d$
	d > 1328 ft	$NEW = d^3/5,832$

(Changed as of the 319th Board Meeting)

Table C9.T5. Intermagazine Hazard Factors and Distances for Hazard Division 1.1

Use Part A of this table to find the hazard factor, K, corresponding to the type of PES and ES. Use the column for this hazard factor in Part B to determine the appropriate distance for the next explosive weight in the PES.

Legend: S – Side; R – Rear; F – Front; B –barricaded; U – Unbarricaded

ECM – Earth-covered Magazine; AG – Aboveground; HPM – High Performance Magazine;

PES – Potential Explosion Site; ES – Exposed Site

Part A – Hazard Factors (K)[1]

FROM PES → / TO ES ↓		ECM				AG Magazine[3]		Modules and/or Cells	*HP Magazine[8]*	
		S	R	F(B)	F(U)	B	U	B or U	*S,R*	*F[9]*
ECM[2], (7 Bar)	S	1.25	1.25	2.75	2.75	4.5	4.5	4.5	*1.25*	*2.75*
	R	1.25	1.25	2	2	4.5	4.5	4.5	*1.25*	*2*
	FU	2.75	2	6	6	6	6	6	*2.75*	*6*
	FB[4]	2.75	2	4.5	6	4.5	6	6	*2.75*	*6*
ECM[2], (3 Bar)	S	1.25	1.25	2.75	2.75	6	6	6	*1.25*	*2.75*
	R	1.25	1.25	2	2	6	6	6	*1.25*	*2*
	FU	4.5	4.5	6	9	6	9	9	*4.5*	*9*
	FB[4]	4.5	4.5	6	6	6	6	6	*4.5*	*6*
ECM[2], (Undefined)	S	1.25[5] 2[6]	1.25[5] 2[6]	4.5[5] 6[6]	4.5[5] 6[6]	6	6	6	*1.25*	*4.5*
	R	1.25	1.25	2	2	6	6	6	*1.25*	*2*
	FU	6	6	6	11	6	11	6	*6*	*11*
	FB[4]	6	6	6	6	6	6	6	*6*	*6*
AG Magazine[3]	U	6	6	6	11	6	11	6	*6*	*11*
	B	6	6	6	6	6	6	6	*6*	*6*
Modules and/or cells	B	1.25	1.25	6	6	6	6	1.1[7]	*1.25*	*6*
HP Magazine[8]	*S,R,F[10]*	*1.25*	*1.25*	*2.75*	*2.75*	*4.5*	*4.5*	*4.5*	*1.25*	*2.75*

Notes:

1. Except as noted, K-factors for ECMs and AG Magazines are applicable for NEW up to 500,000 lb. in the PES. NEW in a Module and/or Cell is limited to 250,000 lb.

2. *Descriptions of the earth-covered magazines are in subsection C5.2.1 of Chapter C5.*

3. *Aboveground magazines are all types of above grade (not earth-covered) magazines or storage pads.*

4. *Those barricades serve to mitigate both fragments and overpressure hazards. See Chapter 5, sectionC5.3. for their requirements.*

5. Use this K-factor for NEW in PES up to 250,000 lb.

6. Use this K-factor for NEW in PES above 250,000 lb.

7. Modules and/or Cells are defined in Chapter 5, subsection C5.2.2.

8. A description of the HPM is in subsection C5.2.4. The MCE in the HPM is 60,000 lbs.

9. The unbarricaded front (entrance to Loading Dock) is a factor when the HPM is the PES because the MCE includes explosives at the loading dock. The K-factors have been determined accordingly.

10. The storage areas in the HPM are barricaded on all sides and protected by a reinforced concrete cover. All directions are therefore considered to be Side, S, orientations when it is the ES.

Table C9.T5. Intermagazine Hazard Factors and Distances for Hazard Division 1.1 Part B - Distance in Feet (Sheet 1)

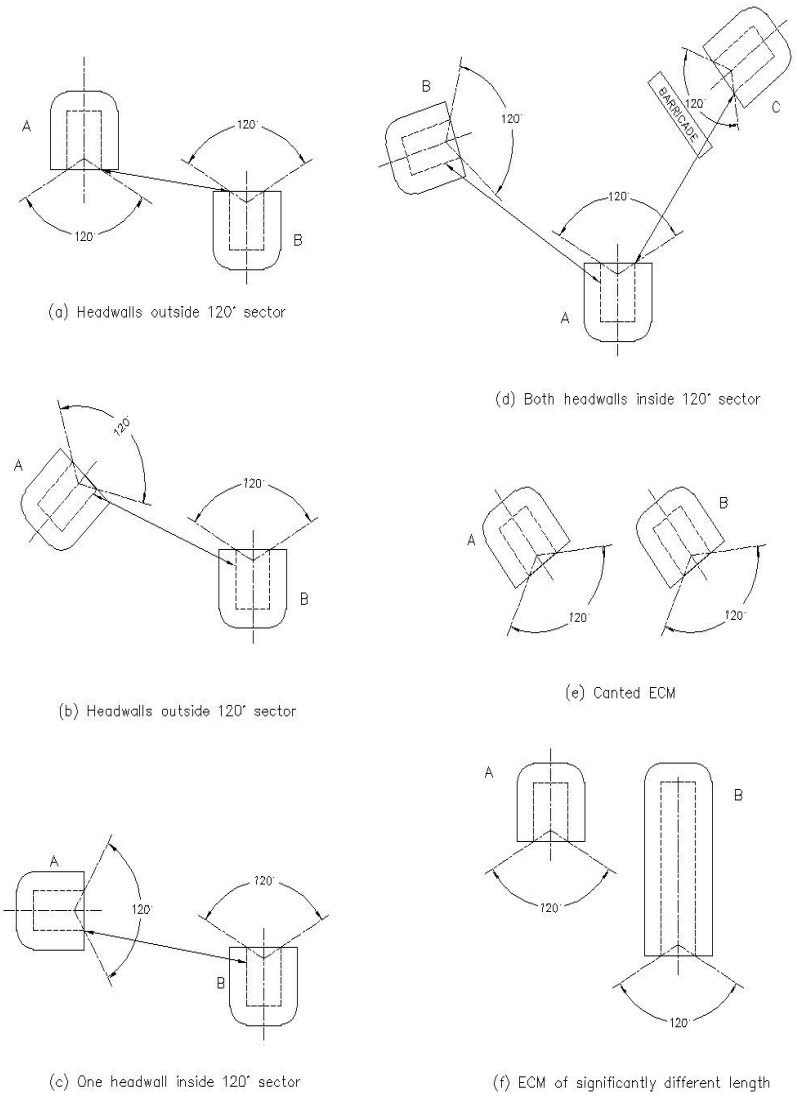
Net Expl. Wt. (lb)	Hazard Factor (K) from Part A										
	1.1	1.25	2	2.75	4	4.5	5	6	8	*9*	11
100	7	7	9	13	19	21	23	28	37	*42*	51
110	7	7	10	13	19	22	24	29	38	*43*	53
120	7	7	10	14	20	22	25	30	39	*44*	54
140	7	7	10	14	21	23	26	31	42	*47*	57
150	7	7	11	15	21	24	27	32	43	*48*	58
170	7	7	11	15	22	25	28	33	44	*50*	61
190	7	7	11	16	23	26	29	34	46	*52*	63
220	7	8	12	17	24	27	30	36	48	*54*	66
250	7	8	13	17	25	28	31	38	50	*57*	69
280	7	8	13	18	26	29	33	39	52	*59*	72
310	7	8	14	19	27	30	34	41	54	*61*	74
350	8	9	14	19	28	32	35	42	56	*63*	78
390	8	9	15	20	29	33	37	44	58	*66*	80
440	8	10	15	21	30	34	38	46	61	*68*	84
500	9	10	16	22	32	36	40	48	63	*71*	87
560	9	10	16	23	33	37	41	49	66	*74*	91
630	9	11	17	24	34	39	43	51	69	*77*	94
700	10	11	18	24	36	40	44	53	71	*80*	98
790	10	12	18	25	37	42	46	55	74	*83*	102
890	11	12	19	26	38	43	48	58	77	*87*	106
1,000	11	13	20	28	40	45	50	60	80	*90*	110
1,100	11	13	21	28	41	46	52	62	83	*93*	114
1,200	12	13	21	29	43	48	53	64	85	*96*	117
1,400	12	14	22	31	45	50	56	67	89	*101*	123
1,500	13	14	23	31	46	52	57	69	92	*103*	126
1,700	13	15	24	33	48	54	60	72	95	*107*	131
1,900	14	15	25	34	50	56	62	74	99	*111*	136
2,200	14	16	26	36	52	59	65	78	104	*117*	143
2,500	15	17	27	37	54	61	68	81	109	*122*	149
2,800	16	18	28	39	56	63	70	85	113	*127*	155
3,100	16	18	29	40	58	66	73	87	117	*131*	160
3,500	17	19	30	42	61	68	76	91	121	*137*	167
3,900	17	20	31	43	63	71	79	94	126	*142*	173
4,400	18	20	33	45	66	74	82	98	131	*147*	180
5,000	19	21	34	47	68	77	85	103	137	*154*	188
5,600	20	22	36	49	71	80	89	107	142	*160*	195
6,300	20	23	37	51	74	83	92	111	148	*166*	203
7,000	21	24	38	53	77	86	96	115	153	*172*	210
7,900	22	25	40	55	80	90	100	119	159	*179*	219
8,900	23	26	41	57	83	93	104	124	166	*187*	228
10,000	24	27	43	59	86	97	108	129	172	*194*	237

Table C9.T5. Intermagazine Hazard Factors and Distances for Hazard Division 1.1 Part B - Distance in Feet (Sheet 2)

Net Expl. Wt. (lb)	Hazard Factor (K) from Part A										
	1.1	1.25	2	2.75	4	4.5	5	6	8	*9*	11
10,000	24	27	43	59	86	97	108	129	172	*194*	237
11,000	24	28	44	61	89	100	111	133	178	*200*	245
12,000	25	29	46	63	92	103	114	137	183	*206*	252
14,000	27	30	48	66	96	108	121	145	193	*217*	265
15,000	27	31	49	68	99	111	123	148	197	*222*	271
17,000	28	32	51	71	103	116	129	154	206	*231*	283
19,000	29	33	53	73	107	120	133	160	213	*240*	294
22,000	31	35	56	77	112	126	140	168	224	*252*	308
25,000	32	37	58	80	117	132	146	175	234	*263*	322
28,000	33	38	61	84	121	137	152	182	243	*273*	334
31,000	35	39	63	86	126	141	157	188	251	*283*	346
35,000	36	41	65	90	131	147	164	196	262	*294*	360
39,000	37	42	68	93	136	153	170	203	271	*305*	373
44,000	39	44	71	97	141	159	177	212	282	*318*	388
50,000	41	46	74	101	147	166	184	221	295	*332*	405
56,000	42	48	77	105	153	172	191	230	306	*344*	421
63,000	44	50	80	109	159	179	199	239	318	*358*	438
70,000	45	52	82	113	165	185	206	247	330	*371*	453
79,000	47	54	86	118	172	193	215	257	343	*386*	472
89,000	49	56	89	123	179	201	223	268	357	*402*	491
100,000	51	58	93	128	186	209	232	278	371	*418*	511
110,000	53	60	96	132	192	216	240	287	383	*431*	527
120,000	54	62	99	136	197	222	247	296	395	*444*	543
140,000	57	65	104	143	208	234	260	312	415	*467*	571
150,000	58	66	106	146	213	239	266	319	425	*478*	584
170,000	61	69	111	152	222	249	277	332	443	*499*	609
190,000	63	72	115	158	230	259	287	345	460	*517*	632
220,000	66	75	121	166	241	272	302	362	483	*543*	664
250,000	69	79	126	173	252	283	315	378	504	*567*	693
280,000	72	82	131	180	262	294	327	393	523	*589*	720
310,000	74	85	135	186	271	305	338	406	541	*609*	744
350,000	78	88	141	194	282	317	352	423	564	*634*	775
390,000	80	91	146	201	292	329	365	438	584	*658*	804
440,000	84	95	152	209	304	342	380	456	608	*685*	837
500,000	87	99	159	218	317	357	397	476	635	*714*	873
560,000	91	103	165	227	330	371	412	495	659	*742*	907
630,000	94	107	171	236	343	386	429	514	686	*772*	943
700,000	98	111	178	244	355	400	444	533	710	*799*	977
790,000	102	116	185	254	370	416	462	555	740	*832*	1017
890,000	106	120	192	265	385	433	481	577	770	*866*	1058
1,000,000	110	125	200	275	400	450	500	600	800	*900*	1100

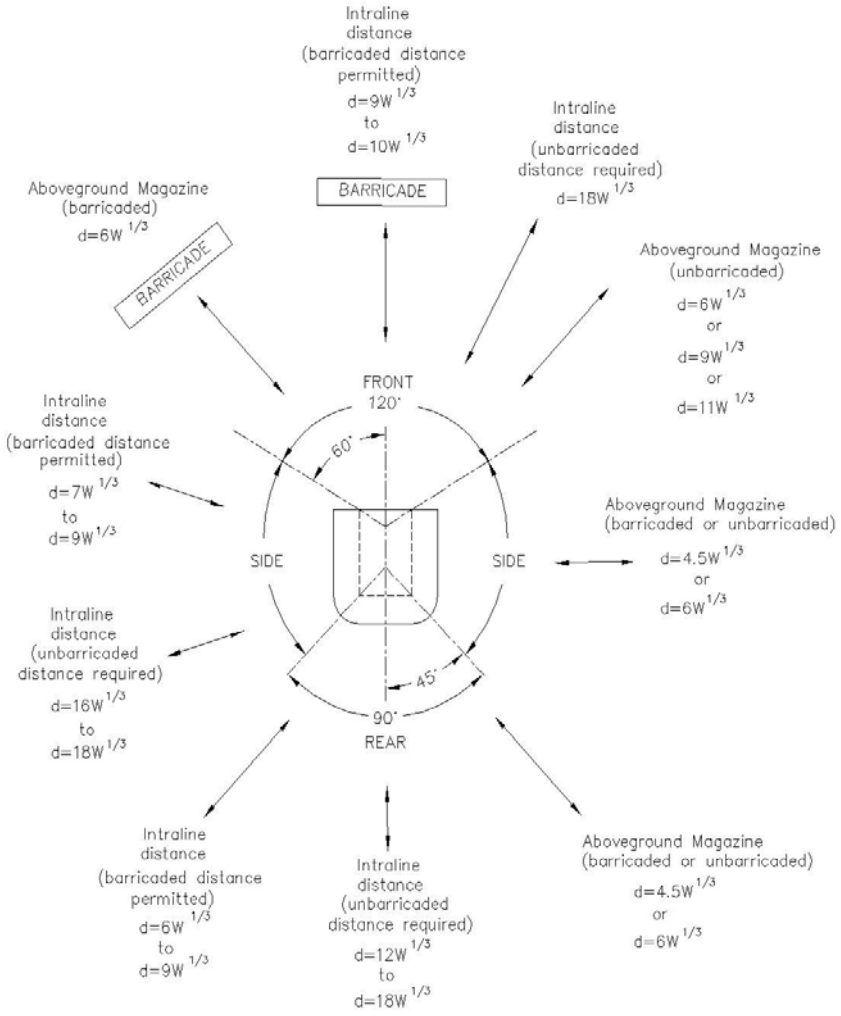
Table C9.T5. Intermagazine Hazard Factors and Distances for Hazard Division 1.1 Part B - Distance in Feet (Sheet 3)

Net Expl. Wt. (lb)	Hazard Factor (K) from Part A										
	1.1	1.25	2	2.75	4	4.5	5	6	8	*9*	11
1,000,000	110	125	200	275	400	450	500	600	800	*900*	1100
1,100,000	114	129	206	284	413	465	516	619	826	*929*	1136
1,200,000	117	133	213	292	425	478	531	638	850	*956*	1169
1,400,000	123	140	224	308	447	503	559	671	895	*1007*	1231
1,500,000	126	143	229	315	458	515	572	687	916	*1030*	1259
1,700,000	131	149	239	328	477	537	597	716	955	*1074*	1313
1,900,000	136	155	248	341	495	557	619	743	991	*1115*	1362
2,200,000	143	163	260	358	520	585	650	780	1040	*1171*	1431
2,500,000	149	170	271	373	543	611	679	814	1086	*1221*	1493
2,800,000	155	176	282	388	564	634	705	846	1128	*1269*	1550
3,100,000	160	182	292	401	583	656	729	875	1166	*1312*	1604
3,500,000	167	190	304	418	607	683	759	911	1215	*1366*	1670
3,900,000	173	197	315	433	630	708	787	944	1259	*1417*	1731
4,400,000	180	205	328	451	655	737	819	983	1311	*1475*	1803
5,000,000	188	214	342	470	684	769	855	1026	1368	*1539*	1881
5,600,000	195	222	355	488	710	799	888	1065	1421	*1598*	1953
6,300,000	203	231	369	508	739	831	923	1108	1478	*1662*	2032
7,000,000	210	239	383	526	765	861	956	1148	1530	*1722*	2104
7,900,000	219	249	398	548	797	896	996	1195	1593	*1792*	2191
8,900,000	228	259	414	570	829	933	1036	1243	1658	*1865*	2280
10,000,000	237	269	431	592	862	969	1077	1293	1724	*1939*	2370
11,000,000	245	278	445	612	890	1001	1112	1334	1779	*2002*	2446
12,000,000	252	286	458	630	916	1030	1145	1374	1832	*2060*	2518
14,000,000	265	301	482	663	964	1085	1205	1446	1928	*2169*	2651
15,000,000	271	308	493	678	986	1110	1233	1480	1973	*2220*	2713



NOTE: See Table C9.T5 for applicable separation distances between ECM.

Figure C9.F1.(a)-(f) Orientation Effects ***on Intermagazine Distance***



NOTES:

1. See C9.3.1.2. for application of intraline and barricaded intraline distances from an ECM.
2. See C9.3.1.3.5. for application of barricaded intraline and barricaded intermagazine distances from an ECM.
3. See C2.4.1. and C2.4.2. for permissible intraline and barricaded intraline exposures.

Figure C9.F1.(g) Orientation Effects on Intermagazine Distance

(Approved by correspondence July 5, 2000)

C9.3.2. Hazard Division 1.2 (Tables C9.T6. through C9.T9.)

(Changed by 322nd Board Meeting)

C9.3.2.1. **GENERAL**.

C9.3.2.1.1. The HD 1.2 hazard classification is given to items configured for storage and transportation that do not mass detonate when a single item or package in a stack is initiated. Explosions involving the items result in their burning and exploding progressively with no more than a few at a time reacting. These reactions will project fragments, firebrands, and unexploded items from the explosion site. Blast effects are limited to the immediate vicinity and are not the primary hazard.

C9.3.2.1.2. Small quantities of HD 1.2.1 (≤ 450 pounds NEW), in certain packaging configurations, will react in a manner more typical of an HD 1.1 event. When located in structures that stop primary fragments, but which generate a secondary debris hazard (e.g. certain ECM and hardened structures), the structural damage and debris hazards produced from these events again are more characteristic of an HD 1.1 explosion, rather than the progressive nature of an HD 1.2.1 event, as described above. When the NEW and the MCE of the packaged HD 1.2.1 items fall within the ranges specified in equation {NEW ≤ MCE ≤ 450 lbs}, the HD 1.2.1 will be treated as HD 1.1 and the criteria of C2.5.2.3.1.1.1, as applicable, will be used. If they fall outside the ranges of the equation, then the criteria of C9.T8 will be applied.

C9.3.2.2. The Net Explosive Weight (NEW) of an item (used for transportation) is the sum of the weight of the HD 1.1 and 1.3 material contained in an item. The Net Explosive Weight for Quantity Distance (NEWQD) for an item is equal to NEW (NEWQD = NEW) unless testing has been conducted. Based on testing, the NEWQD may include a reduced contribution (less than or equal to 100%) from the HD 1.3 material as a result of the HD 1.1 material being functioned. The NEWQD should be determined by the Single Package Test (UN Test 6 (a) or its equivalent), not the Bonfire Test (UN Test 6 (c)). The NEWQD for a specific item may be obtained from the Joint Hazard Classification System (JHCS). The effects produced by the functioning of HD 1.2 items vary with the size and weight of the item. HD 1.2 ammunition is separated into two sub-divisions in order to account for the differences in magnitude of these effects for purposes of setting quantity-distance criteria. The more hazardous items are referred to as HD 1.2.1 items and have an NEWQD greater than 1.60 pounds. The less hazardous items, referred to hereafter as HD 1.2.2, have an NEWQD less than or equal to 1.60 pounds. These two HD 1.2 sub-divisions are shown below with their definitions:

HD 1.2.1: *NEWQD > 1.60 pounds*
HD 1.2.2: *NEWQD ≤ 1.60 pounds*

It is important not to exaggerate the significance of the value of 1.60 pounds used above. It is based on a break point in the database supporting the quantity-distance relationships and tables and the NEWQD of the rounds tested. If comprehensive data are available for a particular item,

then the item may be placed in that category of HD 1.2 supported by the data and allocated the relevant quantity-distances.

C9.3.2.3. The Maximum Credible Event (MCE) for HD 1.2.1 is the NEWQD of an item times the number of items in three unpalletized, outer shipping packages, unless a different MCE is demonstrated by testing or analogy. The authorized MCE for a specific HD 1.2.1 item is listed in the Joint Hazard Classification System (JHCS) (reference (e)).

C9.3.2.4. The quantity distances specified for HD 1.2 ammunition achieve the desired degree of protection against immediate hazards from an incident. Events involving HD 1.2 items lob large amounts of unexploded rounds, components, and subassemblies, which will remain hazardous after impact. Such items are likely to be more hazardous than in their original state because of possible damage to fuze safety devices or other features by heat and impact. Many types of ammunition containing sub-munitions, such as cluster bombs, can be expected to be projected out to distances as great as the relevant inhabited building distances. Furthermore, it is impractical to specify quantity distances which allow for the maximum possible flight ranges of propulsive items.

C9.3.2.5. Tables C9.T6A. and C9.T6B. and Table C9.T7. provide the appropriate inhabited building distances (IBD), public traffic route distances (PTR), and intraline distances (ILD) for HD 1.2.1 and HD 1.2.2 ammunition, respectively. When HD 1.2.1 items are stored in structures which may contribute to the debris hazard, the IBD is determined by using the larger of the following two distances: either that given in Table C9.T6A. for the appropriate Explosive Weight (number of items x NEWQD) or that given in Table C9.T6B. for the appropriate MCE.

C9.3.2.6. Intermagazine distances (IMD) are dependent upon the types of structures acting as both the Potential Explosion Site (PES) and the Exposed Site (ES). Table C9.T8. provides a matrix of all the appropriate separations for the various combinations of ES and PES.

C9.3.2.7. PTR distances given in Tables C9.T6., C9.T7. and C9.T8. give consideration to the transient nature of the exposure in the same manner as for HD 1.1. PTR distance is computed as 60% of the IBD for items in this hazard division, with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L) in Table C9.T8.

C9.3.2.8. ILD given in Tables C9.T6. and C9.T7. and C9.T8. take into account the progressive nature of explosions involving these items (normally resulting from fire spread), up to the magnitude of the MCE, and the ability to evacuate personnel from endangered areas before the progression involves large numbers of items. Exposed structures may be extensively damaged by projections and delayed propagation of explosions may occur due to the ignition of combustibles by projections. ILD is computed as 36% of the IBD for items of this HD, with a minimum distance equal to the Intermagazine Distances given in Table C9.T8. for the applicable PES-ES combination.

C9.3.2.9. When storing mixed sub-divisions of HD 1.2 ammunition (HD 1.2.1

and HD 1.2.2), the following rule shall apply: Consider each sub-division separately and apply the greater of the two distances. The general mixing rules for HD 1.2 ammunition are given in Table C9.T9.

C9.3.2.10. For reasons of operational necessity, limited quantities of HD 1.2.2 items may be stored in facilities such as hangars, troop buildings, and manufacturing or operating buildings without regard to quantity distance. Fragmentation shielding will be provided.

C9.3.2.11. Unit Risk HD 1.2 is a special storage sub-division (HD 1.2.3) for ammunition that satisfies either of the following sets of criteria:

C9.3.2.11.1. Ammunition that satisfies the criteria for HD 1.6 with the exception of containing a non-EIDS device, or

C9.3.2.11.2. Ammunition that does not exhibit any sympathetic detonation response in the stack test (United Nations (UN) Test 6(b)) or any reaction more severe than burning in the external fire test (UN Test 6(c)), bullet impact test (UN Test 7(j)), and the slow cook-off test (UN Test 7(h)).

(Approved at 320th Board Meeting)

C9.3.2.12. The IBD for Unit Risk HD 1.2 (HD 1.2.3) is determined using Table C9.T10 (HD 1.3 Quantity-Distances) for the NEWQD of the HD 1.2.3 item multiplied by the number of rounds present, but with a minimum IBD determined as follows: If the items are in a structure that can interrupt primary fragments and can contribute debris, the minimum IBD is the hazardous debris distance given in Table C9.T6B for an MCE equal to the NEWQD of a single round. If the items are in the open or in a light structure that will not interrupt primary fragments, the minimum IBD is the hazardous primary fragment distance based on the HD 1.1 hazardous fragment areal number density criteria applied to a single HD 1.2.3 item. The hazardous fragment distance applicable to items in the open is specified in hundreds of feet in parentheses as "(xx) 1.2.3." PTR for HD 1.2.3 is equal to 60% of IBD. ILD is computed as 36% of IBD, with a minimum distance equal to the Intermagazine Distance (IMD). IMD is given in Table C9.T8. For any specific quantity or distance determination, as an alternative to the preceding HD 1.2.3 QD criteria, when an increase in the allowable quantity or a reduction in the required distance will result, items hazard classified as HD 1.2.3 may be treated as follows: If the single-round NEWQD is greater than 1.6 pounds, consider the items as HD 1.2.1 (use the total NEWQD present, with an MCE equal to the NEWQD of one round). If the single-round NEWQD is equal to or less than 1.6 pounds, consider the items as HD 1.2.2, based on the total NEWQD present."

C9.3.2.13. For storage of mixed Unit Risk HD 1.2 (HD 1.2.3) ammunition, multiply the NEWQD for the HD 1.2.3 items by the corresponding number of HD 1.2.3 rounds and use Table C9.T10. with a hazardous fragment distance based on the largest hazardous fragment distance for the HD 1.2.3 ammunition in storage. When HD 1.2.3 ammunition is located with any other Hazard Division 1.2 sub-division, use the distances given in Table C9.T9.

When HD 1.2.3 ammunition is located with any other HD ammunition, the HD 1.2.3 ammunition is considered HD 1.2 (HD 1.2.1 or HD 1.2.2, according to NEWQD) for quantity-distance purposes. The mixing rules provided in subsection C9.2.1. above then apply to the combination of the hazard divisions.

C9.3.2.14. HD 1.2 ammunition in the current inventory with IBD given in hundreds of feet and presented in parentheses in the format HD (xx)1.2, need not use the quantity-distance criteria specified above. Instead, constant value quantity-distance criteria for these items maybe specified as follows: IBD is the distance specified in hundreds of feet (in parentheses); PTR is computed as 60% of IBD; ILD is computed as 36% of IBD, with a minimum distance equal to the Intermagazine Distances given in Table C9.T8.

Table C9.T6A. Hazard Sub-Division 1.2.1 Quantity-Distances (IBD, PTR, ILD) for Munitions With NEWQD > 1.60 Pounds

EXPLOSIVE WEIGHT [1] (lbs)	IBD [2,3,4] (ft)	PTR [5] (ft)	ILD [6] (ft)	EXPLOSIVE WEIGHT [1] (lbs)	IBD [2,3,4] (ft)	PTR [5] (ft)	ILD [6] (ft)
				7,000	1033	620	372
2	200	200	200	8,000	1055	633	380
5	200	200	200	9,000	1074	644	387
10	200	200	200	10,000	1091	654	393
20	200	200	200	15,000	1154	693	416
40	200	200	200	20,000	1199	719	432
60	200	200	200	25,000	1233	740	444
80	224	200	200	30,000	1260	756	454
100	268	200	200	40,000	1303	782	469
150	348	209	200	50,000	1335	801	481
200	404	242	200	60,000	1362	817	490
300	481	289	200	70,000	1384	830	498
400	535	321	200	80,000	1402	841	505
600	610	366	220	90,000	1419	851	511
800	662	397	238	100,000	1434	860	516
1,000	702	421	253	150,000	1489	894	536
1,500	774	464	279	200,000	1528	917	550
2,000	824	494	297	250,000	1558	935	561
2,500	862	517	310	300,000	1582	949	569
3,000	893	536	322	350,000	1601	961	577
3,500	919	551	331	400,000	1619	971	583
4,000	941	565	339	450,000	1633	980	588
5,000	978	587	352	500,000	1646	988	593
6,000	1008	605	363	>500,000	Note 4	Note 5	Note 6

NOTES

1. *Explosive Weight = Number of Items x NEWQD.*
2. *IBD = -735.186 + [237.559 x (ln(Number of items x NEWQD))] – [4.274 x (ln(Number of items x NEWQD))^2], with a minimum of 200 feet; IBD in feet, NEWQD in pounds; ln is natural logarithm. [71 < explosive weight]*
3. *Number of items x NEWQD = exp[27.791 – (600.392 – 0.234 x IBD)$^{1/2}$];IBD in feet, NEWQD in pounds; exp (x) is e^x. [200 < IBD < 2016]*

4. *Use of equations given in Notes (2) and (3) to determine other IBD-weight combinations is allowed.*

5. *PTR = 60% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L) in Table C9.T8. For other structures as either ES or PES, see Table C9.T8.*

6. *ILD = 36% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for the applicable PES-ES combination. For structures other than AGS(L) as either ES or PES, see Table C9.T8.*

GENERAL COMMENTS

a. *The quantity-distance criteria for HD 1.2.1 items are based on the hazards from primary fragments. When stored in structures which may contribute to the debris hazard (secondary fragments), the IBD for HD 1.2.1 items whose MCE is greater than 31 pounds is determined by using the larger of the following two distances: those given in this table for the appropriate Explosive Weight or those given in Table C9.T6B. for the appropriate MCE. Structures that may contribute to the debris hazard for storage of HD 1.2.1 ammunition include: (a) all earth-covered magazines (ECMs) – Frontal exposure only. Side and rear exposures have fixed minimum distances for IBD; (b) all aboveground sites (AGSs)—Including heavy wall (H), heavy wall/roof (H/R), and light wall (L) as defined in Table C9.T8., unless data/analyses are provided to show that the structural debris contribution is less. Note that ILD and PTR are based on 36% and 60%, respectively, of the applicable IBD as determined in this note with the following minimum distances: ILD minimum distances are given in Table C9.T8. for applicable PES-ES combinations and PTR minimum distances are given in Table C9.T8. for AGS(L).*

b. *See Table C9.T8. for a summary of Intermagazine Distances (IMD) and minimum distances for ILD and PTR.*

Table C9.T6B. Hazardous Debris Distances for HD 1.2.1 Items Stored in Structures Which Can Conribute to the Debris Hazard

MCE (lbs)	HAZARDOUS DEBRIS DISTANCE[1,2] (ft)	PTR[4] (ft)	ILD[5] (ft)
≤ 31	200	200	200
35	249	200	200
40	301	200	200
45	347	208	200
50	388	233	200
75	546	328	200
100	658	395	237
125	744	446	268
150	815	489	293
175	875	525	315
200	927	556	334
225	973	584	350
250	1014	608	365
275	1051	631	378
300	1085	651	391
325	1116	670	402
350	1145	687	412
375	1172	703	422
400	1197	718	431
425	1220	732	439
450	1243	746	447
>450	1250	750	450

NOTES

1. Hazardous Debris Distance = -1133.9 + [389 x ln(MCE)]; [31 < MCE ≤ 450]
   MCE in pounds, Hazardous Debris Distance in feet with a minimum distance of 200 feet; ln is natural logarithm.

2. MCE = exp [(Hazardous Debris Distance/389) + 2.914]; [200 < Hazardous Debris Distance ≤ 1250]MCE in pounds, Hazardous Debris Distance in feet; exp [x] is e^x.

3. Use of equations given in Notes (1) and (2) to determine other Hazardous Debris Distance-MCE combinations is allowed.

4. PTR = 60% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L) in Table C9.T8. For other structures as either ES or PES, see Table C9.T8.

5. ILD = 36% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for the applicable PES-ES combination. For structures other than AGS(L) as either ES or PES, see Table C9.T8.

GENERAL COMMENTS

a. The quantity-distance criteria for HD 1.2.1 items are based on the hazards from primary fragments. When stored in structures which may contribute to the debris hazard (secondary fragments), the IBD for HD 1.2.1 items whose MCE is greater than 31 pounds is determined by using the larger of the following two distances: those given in Table C9.T6A. for the appropriate Explosive Weight or those given in this table for the appropriate MCE. Structures that may contribute to the debris hazard for storage of HD 1.2.1 ammunition include: (a) all earth-covered magazines (ECMs) – Frontal exposure only. Side and rear exposures have fixed minimum distances for IBD; (b) all aboveground sites (AGSs)—Including heavy wall (H), heavy wall/roof (H/R), and light wall (L) as defined in Table C9.T8., unless data/analyses are provided to show that the structural debris contribution is less. Note that ILD and PTR are based on 36% and 60%, respectively, of the applicable IBD as determined in this note with the following minimum distances: ILD minimum distances are given in Table C9.T8. for applicable PES-ES combinations and PTR minimum distances are given in Table C9.T8. for AGS(L).

b. See Table C9.T8. for a summary of Intermagazine Distances (IMD) and minimum distances for ILD and PTR.

Table C9.T7. Hazard Sub-Division 1.2.2 Quantity-Distances (IBD, PTR, ILD) for Munitions With NEWQD < 1.60 Pounds

EXPLOSIVE WEIGHT [1] (lbs)	IBD [2,3,4] (ft)	PTR [5] (ft)	ILD [6] (ft)	EXPLOSIVE WEIGHT [1] (lbs)	IBD [2,3,4] (ft)	PTR [5] (ft)	ILD [6] (ft)
1	100	100	100	7,000	366	220	132
2	100	100	100	8,000	376	226	135
5	100	100	100	9,000	385	231	139
10	100	100	100	10,000	394	236	142
20	100	100	100	15,000	427	256	154
40	113	100	100	20,000	451	271	162
60	123	100	100	25,000	471	282	169
80	131	100	100	30,000	487	292	175
100	138	100	100	40,000	514	308	185
150	152	100	100	50,000	535	321	193
200	162	100	100	60,000	553	332	199
300	179	107	100	70,000	568	341	204
400	192	115	100	80,000	581	349	209
600	211	127	100	90,000	593	356	214
800	226	136	100	100,000	604	362	217
1,000	238	143	100	150,000	647	388	233
1,500	262	157	100	200,000	678	407	244
2,000	279	168	101	250,000	703	422	253
2,500	294	176	106	300,000	723	434	260
3,000	306	183	110	350,000	741	445	267
3,500	316	190	114	400,000	757	454	272
4,000	325	195	117	450,000	771	462	277
5,000	341	205	123	500,000	783	470	282
6,000	355	213	128	>500,000	Note 4	Note 5	Note 6

NOTES

1. *Explosive Weight = Number of Items x NEWQD.*

2. *(IBD = 101.649 - [15.934 x (ln(Number of items x NEWQD))] + [5.173 x (ln(Number of items x NEWQD))^2], with a minimum of 100 feet; IBD in feet, NEWQD in pounds; ln is natural logarithm. [20 < Explosive Weight]*

3. *Number of items x NEWQD = exp [1.5401 + (-17.278 + 0.1933 x IBD)$^{1/2}$];IBD in feet, NEWQD in pounds; exp (x) is e^x. [100 <IBD < 1240]*

4. *Use of equations given in Notes (2) and (3) to determine other IBD-weight combinations is allowed*

5. *(PTR = 60% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L) in Table C9.T8. For other structures as either ES or PES, see Table C9.T8.*

6. *ILD = 36% of IBD with a minimum distance equal to the Intermagazine Distance given in Table C9.T8. for the applicable PES-ES combination. For structures other than AGS (L) as either ES or PES, see Table C9.T8.*

GENERAL COMMENTS

a. *The quantity-distance criteria for HD 1.2.2 items are based on the hazards from primary fragments.*

b. *See Table C9.T8. for a summary of Intermagazine Distances (IMD) and minimum distances for ILD and PTR.*

To EXPOSED SITE (ES)		From POTENTIAL EXPLOSION SITE (PES)				
		ECM		AGS		
		S or R	F	(H)	(H/R)	(L)
ECM (7 bar/3 bar) (IMD)	S	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	R	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FU	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FB	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
ECM (Undefined) (IMD)	S	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	R	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FU	0 (note 1)	200/300/100	200/300/100	200/300/100	200/300/100
	FB	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
AGS (H/R) (IMD)	U or B	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
AGS (H or L) (IMD)	U or B	0 (note 1)	200/300/100	200/300/100	0 (note 1)	200/300/100
ILD [5]		0 (Note 1)	Note 2	0 (Note 1)	0 (Note 1)	Note 2
PTR [5]		200/300/100	Note 3	Note 3	Note 3	Note 3
IBD [5]		200/300/100	Note 4	Note 4	Note 4	Note 4

Table C9.T8. Summary of Hazard Sub-Divisions 1.2.1, 1.2.2, and 1.2.3 Quantity-Distances

(NOTE: all distances are in feet)

LEGEND

***S**—Side; **R**—Rear; **F**—Front: **B**—Barricaded; **U**—Unbarricaded; **FU**—Front Unbarricaded; **FB**—Front Barricaded.*

***ECM**—Earth-Covered Magazine (7-bar, 3-bar, undefined refers to the strength of the headwall).*

***AGS**—Aboveground site; aboveground, non earth-covered magazine, structure or storage pad.*

***AGS (H)**—Aboveground site, Heavy Wall; Buildings with wall thickness ≥ 12 inches of reinforced concrete; as an ES, door must be barricaded if it faces a PES.*

***AGS (H/R)**—Aboveground site, Heavy Wall and Roof; AGS (H) with roof thickness > 5.9 inches of reinforced concrete;as an ES, door must be barricaded if it faces a PES; side/rear exposures may or may not be barricaded.*

***AGS (L)**—Aboveground site, Light; Light structure, open stack, truck, trailer, or railcar.*

***IMD**—Intermagazine Distance; **ILD**—Intraline Distance;*

***PTR**—Public Traffic Route Distance; **IBD**—Inhabited Building Distance.*

NOTES

1. *Practical considerations such as firefighting and security will dictate specific separation distances as specified by DoD Component.*

2. *ILD = 36% of IBD with a minimum distance equal to the Intermagazine Distance given in this table for the applicable PES-ES combination.*

3. *PTR = 60% of IBD with a minimum distance equal to the Intermagazine Distance given in this table for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L).*

4. *For HD 1.2.1 items, use the larger of the two applicable values given in Tables C9.T6A. and C9.T6B; for HD 1.2.2 items use Table C9.T7.*

5. *See Paragraph C9.3.2.12 for HD 1.2.3.*

(Added by 322nd Board Meeting)

6. *When the NEW and the MCE of the packaged HD 1.2.1 items fall within the ranges specified in equation {NEW ≤ MCE ≤ 450 lbs}, the HD 1.2.1 will be treated as HD 1.1 and the criteria of C2.5.2.3.1.1.1, as applicable, will be used (see C9.3.2.1.2).*

GENERAL COMMENTS

(Approved change 320th Board Meeting)

a. *For PES-ES combinations where three distances are given, the first refers to a PES containing HD 1.2.1 items with an MCE < 100 pounds, the second to a PES containing HD 1.2.1 items with an MCE ≥ 100 pounds, and the third refers to a PES containing HD 1.2.2 items. Where three Intermagazine Distances are given, the IM Distance from a PES containing only HD 1.2.3 items to an ES containing other than HD 1.2.3 is K11 based on the NEWQD of a single round of the largest (greatest NEWQD) HD 1.2.3 item in the PES.*

b. For an ES containing only HD 1.2.3 items, the IMD from any PES to such an ES is 0 (Note 1).

Table C9.T9. Hazard Sub-Divisions 1.2.1, 1.2.2, AND 1.2.3 Mixing Rules

HAZARD SUB-DIVISION INVOLVED	DISTANCES TO BE APPLIED
1.2.1	Apply HD 1.2.1 distances[1]
1.2.2	Apply HD 1.2.2 distances[2]
1.2.3	Apply HD 1.2.3 distances[3]
1.2.1 + 1.2.2	Apply greater of two distances
1.2.1 + 1.2.3	Apply greater of two distances
1.2.2 + 1.2.3	Apply greater of two distances

NOTES

1. *HD 1.2.1 distances given in Tables C9.T6A., C9.T6B., and C9.T8.*

2. *HD 1.2.2 distances given in Tables C9.T7. and C9.T8.*

3. *HD 1.2.3 distances given in Table C9.T10. (See paragraph C9.3.2.12.)*

C9.3.3. **Hazard Division 1.3** (Table C9.T10.)

Hazard Division 1.3 includes items that burn vigorously with little or no possibility of extinguishment in storage situations. Explosions normally will be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast overpressure beyond the magazine distance specified in Table C9.T10. A severe hazard of spread of fire may result from tossing about of burning container materials, propellant, or other flaming debris.

C9.3.4. **Hazard Division 1.4** Table C9.T11.)

(Approved at 320th Board Meeting)

C9.3.4.1. HD 1.4 AE presents a fire hazard with minimal blast, fragmentation, or toxic hazards. Facilities for storage and handling of these items shall be located in accordance with Table C9.T11.

C9.3.4.2. Items hazard classified as HD 1.4S (see C3.4.13.) may be stored (including associated handling) without regard to the Q-D criteria in Table C9.T11.

C9.3.5. **Hazard Division 1.6** (Table C9.T12.)

Quantity-distance separations for Hazard Division 1.6 ammunition shall be based on the storage location and configuration. This information is detailed in Table C9.T12. and footnotes thereto. A maximum of 500,000 NEW shall be permitted at any one location. Any special storage configuration and siting approved for Hazard Division 1.1 ammunition or explosives may be used for a storage of like explosive weights of Hazard Division 1.6 ammunition.

C9.3.6. **Hazard Division 6.1**

C9.3.6.1. Hazard Division 6.1 includes items that contain only toxic chemical or riot control agents. Items containing both explosives and toxic chemical or riot control agents may be included in Class 1, Divisions 1 through 4, based on testing in accordance with section C3.7. of Chapter 3.

C9.3.6.2. Hazard zones for toxic chemical agents are determined by the relative toxicity of the agents, the amount released to the atmosphere and the rate at which they are released (that is, evaporation, pressure, or explosive dispersal), terrain features, and meteorological conditions. Hazard zone calculations are based on maximum credible events (MCEs), using "Methodology for Chemical Hazard Prediction" (reference (p)).

C9.3.6.3. Items containing both explosives and toxic chemical agents require application of both the appropriate Hazard Divisions 1.1 thru 1.4 Q-D and the class 6.1 hazard zone distance.

Table C9.T10. Hazard Division 1.3 Quantity-Distances.(Notes 1 and 2)

NEW (lbs)	IBD or PTR[3] (ft)	Above-ground IMD OR ILD[4] (ft)	NEW (lbs)	IBD or PTR[3] (ft)	Above-ground IMD OR ILD[4] (ft)	NEW (lbs)	IBD or PTR[3] (ft)	Above-ground IMD OR ILD[4] (ft)
1,000	75	50	92,000	296	196	560,000	627	413
2,000	86	57	94,000	297	197	570,000	632	415
3,000	96	63	96,000	298	198	580,000	636	418
4,000	106	69	98,000	299	199	590,000	641	420
5,000	115	75	100,000	300	200	600,000	645	422
6,000	123	81	110,000	307	205	610,000	649	424
7,000	130	86	120,000	315	210	620,000	654	426
8,000	137	91	130,000	322	215	630,000	658	428
9,000	144	96	140,000	330	220	640,000	662	430
10,000	150	100	150,000	337	225	650,000	667	432
12,000	159	105	160,000	345	230	660,000	671	435
14,000	168	111	170,000	352	235	670,000	675	437
16,000	176	116	180,000	360	240	680,000	679	439
18,000	183	120	190,000	367	245	690,000	684	441
20,000	190	125	200,000	375	250	700,000	688	443
22,000	195	130	210,000	383	255	710,000	692	445
24,000	201	134	220,000	390	260	720,000	696	447
26,000	206	138	230,000	398	265	730,000	700	449
28,000	210	142	240,000	405	270	740,000	704	451
30,000	215	145	250,000	413	275	750,000	708	453
32,000	219	147	260,000	420	280	760,000	712	455
34,000	224	149	270,000	428	285	770,000	716	457
36,000	228	151	280,000	435	290	780,000	720	459
38,000	231	153	290,000	443	295	790,000	724	461
40,000	235	155	300,000	450	300	800,000	728	463
42,000	238	157	310,000	458	305	810,000	732	465
44,000	242	159	320,000	465	310	820,000	735	467
46,000	245	161	330,000	473	315	830,000	739	469
48,000	247	163	340,000	480	320	840,000	743	471
50,000	250	165	350,000	488	325	850,000	747	472
52,000	252	167	360,000	495	330	860,000	750	474
54,000	254	169	370,000	503	335	870,000	754	476
56,000	256	171	380,000	510	340	880,000	758	478
58,000	258	173	390,000	518	345	890,000	761	480
60,000	260	175	400,000	525	350	900,000	765	482
62,000	262	177	410,000	533	355	910,000	769	484
64,000	264	180	420,000	541	361	920,000	772	486
66,000	266	182	430,000	549	366	930,000	776	487
68,000	268	183	440,000	556	371	940,000	779	489
70,000	270	185	450,000	564	376	950,000	783	491
72,000	272	186	460,000	571	381	960,000	786	493
74,000	274	187	470,000	579	386	970,000	790	495
76,000	276	188	480,000	586	391	980,000	793	496
78,000	278	189	490,000	593	395	990,000	797	498
80,000	280	190	500,000	600	400	1,000,000	800	500
82,000	284	191	510,000	605	402			
84,000	287	192	520,000	609	404			
86,000	290	193	530,000	614	407			
88,000	293	194	540,000	618	409			
90,000	295	195	550,000	623	411			

Notes for Table C9.T10.:

For quantities less than 1,000 lbs, the required distances are those specified for 1,000 lbs. The use of lesser distances may be approved when supported by test data and/or analysis.

Linear interpolation of NEW quantities between table entries is permitted.

For quantities above 1,000,000 lbs, the values given above will be extrapolated by means of cube-root scaling as follows:

For inhabited building distance (IBD) and public traffic route (PTR) distance, use $D = 8W^{1/3}$.

For aboveground intermagazine distance (IMD) and intraline distance (ILD), use $D = 5W^{1/3}$.

List of items (examples only): Military pyrotechnics; solid propellants in bulk, in containers, or in ammunition items; and nontoxic chemical ammunition.

1. Items will be placed in this hazard division if they qualify for assignment to it after evaluation in accordance with Chapter 3.

2. For reasons of operational necessity, limited quantities of items in this hazard division, such as document destroyers, signaling devices, riot control munitions and the like, may be stored without regard to quantity-distance in accordance with fire protection regulations in facilities such as hangars, arms rooms, and manufacturing or operating buildings.

3. The same distances are used for IBD and PTR.

4. The same distances are used for aboveground IMD and ILD. Earth-covered buildings may be used to their physical capacity for this hazard division provided they comply with the construction and siting requirements of Chapter 5 and 9, respectively, for Hazard Division 1.1. Earth-covered magazines used to store only Hazard DIvision 1.3 items must be sited for a minimum of 100 lbs of Hazard DIvision 1.1 items using Tables C9.T4. and C9.T5.

(Approved at 320th Board Meeting)

Table C9.T11. Hazard Division 1.4 Quantity-Distances

NEW (lb)	*Inhabited Building Distance (ft)*	*Public Traffic Route Distance (ft)*	*Intraline Distance (ft)* [1]	*Magazine Distance (ft)* [1]	
				Aboveground[2]	*Earth-covered*
For quantities up to 3000 lb[3, 4]	*75*	*75*	*50*	*50*	*0 out the Sides & Rear; use Aboveground Magazine distance out the Front*
For quantities larger than 3000 lb (no upper limit specifically required for safety reasons)	*100*	*100*	*50 (100 if combustible construction*[5]*)*	*50 (100 if combustible construction*[5]*)*	

Notes:

1. *Magazines storing only HD 1.4 AE may be located at these magazine or intraline distances from all other magazines or operating buildings regardless of the hazard division or quantity of explosives authorized in those adjacent structures. Because the HD 1.4 AE may be destroyed as the result of a mishap involving the assets in those adjacent structures, application of this provision must be accepted by the DoD Component on a case-by-case basis with consideration given to the value of HD 1.4 assets at risk.*

2. *HD 1.4 AE may be stored in a general supplies warehouse area rather than in an explosives storage area. When storing in a general supplies warehouse area, any weatherproof warehouse structure may serve as a HD 1.4 magazine. Such a structure shall be separated from all other warehouses by aboveground magazine distance.*

3. *For reasons of operational necessity, limited quantities of HD 1.4 AE, such as small arms ammunition and riot control munitions, may be stored without regard to Q-D within facilities such as hangars, arms rooms, and operating*

buildings. Alternatively, operationally necessary HD 1.4 AE may be stored in small magazines external to those facilities without regard to Q-D.

4. See paragraph C9.2.1.10. for the applicability of HD 1.4 quantity-distance criteria and the determination of NEW when HD 1.4 and other Hazard Division AE are located in the same site.

5. *Wood frame structures are an example of combustible construction. Concrete, masonry, and metal structures are examples of non-combustible construction.*

Table C9.T12. Quantity-Distance Criteria for Hazard Division 1.6 Ammunition

NEW (lbs)	IBD or PTR (ft)	Aboveground IMD or ILD (ft)	NEW (lbs)	IBD or PTR (ft)	Aboveground IMD or ILD (ft)
100	37	23	75,000	337	211
200	47	29	80,000	345	215
300	54	33	85,000	352	220
400	59	37	90,000	359	224
500	64	40	95,000	365	228
600	67	42	100,000	371	232
700	71	44	110,000	383	240
800	74	46	120,000	395	247
900	77	48	125,000	400	250
1,000	80	50	130,000	405	253
2,000	101	63	140,000	415	260
3,000	115	72	150,000	425	266
4,000	127	79	160,000	434	271
5,000	137	86	170,000	443	277
6,000	145	91	175,000	447	280
7,000	153	96	180,000	452	282
8,000	160	100	190,000	460	287
9,000	166	104	200,000	468	292
10,000	172	108	225,000	487	304
15,000	197	123	250,000	504	315
20,000	217	136	275,000	520	325
25,000	234	146	300,000	536	334
30,000	249	155	325,000	550	344
35,000	262	164	350,000	564	352
40,000	274	171	375,000	577	361
45,000	285	178	400,000	589	368
50,000	295	184	425,000	601	376
55,000	304	190	450,000	613	383
60,000	313	196	475,000	624	390
65,000	322	201	500,000	635	397
70,000	330	206			

Notes for Table C9.T12.:

1. The same distances are used for aboveground intermagazine distances (IMD) and intraline distances (ILD). Earth-covered magazines may be used to their physical capacity for this hazard division, provided they comply with the construction and siting requirements of Chapters 5 and 9 for Hazard Division 1.1.

2. For quantities less than 100 lbs, the required distances are those specified for 100 lbs. The use of lesser distances may be approved when supported by test data and/or analysis.
3. Interpolation is permitted. For inhabited building distance (IBD) and public traffic route (PTR) use $D = 8W^{1/3}$. For aboveground IMD and intraline distance (ILD) use $5W^{1/3}$.

4. Unit risk distance for airblast applies as a minimum; that is, for IBD or PTR, $D = 40W^{1/3}$ and for aboveground IMD or ILD, $D = 18W^{1/3}$, based on a single round of ammunition.

5. For Hazard Division 1.6 items packed in non-flammable pallets or packing, stored in earth-covered steel or concrete arch magazines when acceptable to the DoD Component and the DDESB on a site-specific basis, the following quantity-distance criteria apply, unless Table C9.T12. permits a lesser distance requirement; IBD and PTR -- 100 ft; aboveground IMD and ILD -- 50 ft; earth-covered IMD -- No specified requirement.

C9.4. AIRFIELDS, HELIPORTS, AND SEADROMES

C9.4.1. **Scope and Application**

C9.4.1.1. This section applies to ammunition and explosives, which is under the control and custody of DoD personnel, at or near airfields, heliports, and seadromes which are located within the United States and U.S. territories and possessions. *Chapter 10, section C10.5.6.,* applies where these requirements cannot be met in a foreign nation. Its provisions do not apply to explosives items installed on aircraft or contained in survival and rescue kits such as flares, signals, egress system components, squibs, and detonators for jettisoning external stores, engine-starter cartridges, fire extinguisher cartridges, destructors in electronic equipment, explosives components of emergency equipment, and other such items or materials necessary for safe flight operations.

(Approved by correspondence 14 August 2001)

C9.4.1.2. Aircraft loaded with the munitions, shown in subparagraphs C9.4.1.2.1., C9.4.1.2.2. and C9.4.1.2.3., below, are exempt from quantity-distance requirements when evaluated as a PES:

C9.4.1.2.1. HD 1.2.2 - gun ammunition, 30 mm or less.

C9.4.1.2.2. HD 1.3 - Captive missiles or aircraft defensive flare/chaff.

C9.4.1.2.3. HD 1.4 - munition.

C9.4.1.2.4. These aircraft must be parked in designated aircraft parking areas that meet airfield criteria.

C9.4.1.2.5. Uploading and downloading of explosives will be conducted in explosives sited aircraft parking areas with the exception of munitions listed in sub-paragraph C9.4.1.2.1 through C9.4.1.2.3 above. These munitions can be uploaded and downloaded at the designated aircraft parking areas provided that the quantity of munitions involved in the operation is limited to a single aircraft load.

(Changes approved at the 316th Board Meeting)

C9.4.1.3. These Q-Ds shall be applied in conjunction with airfield clearance criteria as prescribed by DoD Components and Federal Aviation Regulations (reference (q)) as follows:

C9.4.1.3.1. For airfields, heliports, and seadromes used exclusively by DoD Components and allied nations military components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters may be located within the

airfield clearance zone insofar as these Q-D standards are concerned, except in the explosives prohibited areas as described in subsection C9.4.3., below.

C9.4.1.3.2. For airfields, heliports, and seadromes not used exclusively by DoD Components and allied nations military components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters shall be located as prescribed in Tables C9.T13. and C9.T14. (Refer to Table C9.T14. first.)

(Added by correspondence December 3, 1998)

C9.4.1.4. The Hardened Aircraft Shelter criteria provided in Chapter 10 is applicable to peacetime operations as well contingency and combat.

C9.4.2. **Measurement of Separation Distances.** In applying Tables C9.T13. and C9.T14., distances shall be measured as follows:

C9.4.2.1. **Loaded Aircraft to Loaded Aircraft.** Measure the shortest distance between explosives on one aircraft to explosives on the adjacent aircraft.

C9.4.2.2. **Ammunition and Explosives Location to Taxiways and Runways.** Measure from the nearest point of the ammunition and explosives location to the nearest point of the taxiway and to the centerline of the runway.

Table C9.T13. Hazard Division 1.1 - Quantity-Distance for Military Aircraft Parking Areas

Net Expl. Wt. (lb)	Distance in ft for specific targets indicated in Table C9.T14.	Net Expl. Wt. (lb)	Distance in ft for specific targets indicated in Table C9.T14.
50	111	5,300	523
58	116	6,300	554
69	123	7,400	585
81	130	8,700	617
95	137	10,000	646
110	144	12,000	687
130	152	14,000	723
150	159	16,000	756
180	169	19,000	801
210	178	22,000	841
250	189	26,000	889
290	199	31,000	942
340	209	37,000	1,000
400	221	43,000	1,051
470	233	51,000	1,113
560	247	60,000	1,174
660	261	70,000	1,236
770	275	83,000	1,309
910	291	97,000	1,378
1,000	300	110,000	1,437
1,200	319	130,000	1,520
1,400	336	150,000	1,594
1,700	358	180,000	1,694
2,000	378	210,000	1,783
2,300	396	250,000	1,890
2,800	423	300,000	2,008
3,300	447	350,000	2,114
3,800	468	410,000	2,229
4,500	495	480,000	2,349
5,300	523	500,000	2,381

Notes:

1. To protect against low-angle, high-speed fragments, barricades should be provided; however, these distances will not be reduced.

2. The distance given for 0 to 50 pounds NEW constitutes the minimum spacing permitted.

3. The minimum fragment distance requirements for Hazard Division 1.1 (see paragraph C2.5.2.3.) do not apply to targets for which this table is used.

Table C9.T14. Application of Ammunition and Explosives Safety Distances (Airfields, Heliports, and Seadromes) (Table entries refer to the key below)

To:	From:				
	Combat Aircraft Parking Area	Ammunition/ Explosives Cargo Area	Ammunition/ Explosives Storage Facility	Ammunition/ Explosives Operating Facility	Ready Ammunition Storage Facility
Combat Aircraft Parking Area	3a	3a	5	5	3a
Ammunition/Explosives Cargo Area	3a	3a	3	3	3a
Ammunition/Explosives Storage Facility	3	3	3	3	3
Ammunition/Explosives Operating Facility	4	4	4	4	4
Ready Ammunition Storage Facility	3	3	3	3	3
Inhabited Building	1	1	1	1	1
Public Traffic Route & Taxiway (joint DoD-Non-DoD use)	2	2	2	2	2
Runway (joint DoD-Non-DoD use)	1	1	1	1	1
Runway/Taxiway (DoD Component use only)	None	None	11	2	None
Aircraft Parking Area	10	10	6	6	10
Aircraft Passenger Loading/Unloading Area	7	7	7	7	7
Recreation Area	8	9	9	9	8

Key to Table C9.T14.:

1. Use appropriate inhabited building distance.

2. Use appropriate public traffic route distance.

(Changes approved at the 316th Board Meeting)

3. For Hazard Division 1.1 explosives, use appropriate intermagazine distance. For Hazard Division 1.2 *(1.2.1, 1.2.2 and/or 1.2.3*), apply note 10, below.

   3.a For Hazard Division 1.1 explosives, use appropriate intermagazine distance. For Hazard Division 1.*2 (1.2.1, 1.2.2, and/or 1.2.3)*, apply note 10, below. Protects against simultaneous detonation of ammunition on adjacent aircraft, but does not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire.

4. Use appropriate intraline distance.

5. Use Table C9.T13. distances for mass-detonating items and appropriate public traffic route distances for nonmass-detonating items.

6. Use Table C9.T13. distances for DoD Component aircraft parking areas, and appropriate inhabited building distance for non-DoD Component aircraft parking areas.

7. Use appropriate public traffic route distances for locations in the open where passengers enplane and deplane; use appropriate inhabited building distance if a structure is included where passengers assemble, such as a passenger terminal building.

8. No distance required to recreational areas that are used exclusively for alert personnel manning the combat-loaded aircraft. Other recreational areas where people are in the open shall be at appropriate public traffic route distance. When structures, including bleacher stands, are a part of such area, appropriate inhabited building distance shall be used.

9. Recreational areas, where people are in the open, shall be at appropriate public traffic route distance. When structures, including bleacher stands are part of such area, appropriate inhabited building distance shall be used.

10. Within these areas of airfields, heliports, and seadromes exclusively used by DoD Components, the separation of aircraft parking areas from combat aircraft parking areas and their ready ammunition storage facilities and ammunition and explosives cargo areas are considered to be a command function. At joint DoD/non-DoD use airfields, heliports, and seadromes, the combat aircraft parking areas and its ready ammunition storage facilities and ammunition and explosives cargo area shall be separated from non-DoD aircraft as specified in item 6., above.

(Approved at 317th Board Meeting)

11. Use $18W^{1/3}$ distances from side or rear of standard earth-cover magazine containing to taxiway; use public traffic route distance from front of earth-covered magazinesor any other storage locations to taxiways;use public traffic route distance from all storage locations to runways.

C9.4.3. **Ammunition and Explosives Prohibited Areas.** All ammunition and explosives shall be prohibited in any area under approach and departure zones of all fixed and rotary wing aircraft landing facilities (DoD, other Federal, joint use and civil). The approach and departure zone surface or areas for aircraft are those so designated and described in detail for the various types of facilities in DoD Component airfield and airspace criteria directives. In general, the approach and departure zone begins near the end of a runway or landing area and extends outward to a given distance along, and symmetrically on each side of, the extended runway centerline or the aircraft approach axis of a heliport. Such zones flare uniformly from the landing area outward to a prescribed limit.

C9.5. PIER AND WHARF FACILITIES

(Approved by 320th Board Meeting)

C9.5.1. **Applicability and Scope.** This section applies to piers and wharves and associated facilities at which ammunition and explosives may be handled, or be present in ships' holds or service conveyances. Its provisions do not apply to ammunition or explosives stored in ships' magazines and intended for the service of shipboard armament or aircraft. However, they do apply to loading, off-loading, stowing, and shifting of such ammunition and explosives, *with the exception of handling 300 pounds NEW or less of Hazard Division 1.3 and 1.4 material necessary for ships' security and safety-at-sea*. Q-Ds herein are for Hazard Division 1.1. Effects of an explosion to be expected when these Q-Ds are applied are described in Chapter 2. If only ammunition and explosives of other hazard divisions are involved, the Q-Ds for such hazards shall be applied as appropriate.

C9.5.2. **Determination of Quantity of Explosives in a Ship**

C9.5.2.1. On board ship, the various types of ammunition and explosives are stored relatively close to each other, and a detonation in the HE part of the cargo may receive considerable support from items that are normally considered to be only fragment or fire hazards; therefore, the total quantity of explosives on board a ship shall be determined in accordance with subsection C9.2.1., above.

C9.5.2.2. When ship units are separated by $11W^{1/3}$ distances or greater, Q-D will be based individually on the quantity of each ship unit. Lesser separation distances require that the explosives in both ship units be totaled for Q-D purposes.

C9.5.3. **Measurement of Separation Distance**

C9.5.3.1. **Ships at a Pier.** Measurement of separation distances between ships shall be from the nearest point of one unit to the nearest point of the other. Movement of railcars or trucks passing through the clear space is considered as an operational risk. It will generally be impracticable to separate berths at a single pier by enough distance to prevent mass detonation of ships containing complete cargoes of Hazard Division 1.1 ammunition. To the extent operationally feasible, therefore, scheduling shall be such as to reduce the number of such exposures and total time that they are required.

C9.5.3.2. **Piers.** The separation distances between piers shall be measured from the nearest point of the ship unit at one pier to the nearest point of the ship unit under consideration at the other pier.

C9.5.3.3. **Anchorages.** Measurements from anchorages generally shall be from the boundary of the area designated for the scuttling site or the explosives anchorage. In the case of the explosives anchorage, the separation distance to outside targets shall depend upon whether:

C9.5.3.3.1. The ship units that are loading or unloading within the explosives anchorage are separated properly, taking into consideration location and the amount of explosives in each ship unit. The ship unit equivalent for an explosives anchorage is a circle, the radius of which is the distance from the mooring buoy or the ship's anchor to the stern of the ship or of the ammunition lighters alongside when riding to the full scope of the chain. To maintain proper separation distance between loading or unloading ship units in the explosives anchorage, the ships shall moor or anchor so that at no time will they have a separation distance less than $11W^{1/3}$ if quantities are not to be totaled.

C9.5.3.3.2. The ships being loaded or unloaded at one area are separated properly from the loaded ships in another area and whether the loaded ships within the loaded ship area are separated properly from each other. If the latter conditions do not apply, the quantity for entering the table shall be the total quantity rather than the unit quantity.

C9.5.3.4. **Dolphins or Interrupted Quays**. Measurement of separation distance between ships moored to dolphins or interrupted quays shall be from the nearest point of one unit to the nearest point of the other.

C9.5.3.5. **Fixed Targets**. The measurement of separation distance from moored ships to fixed targets on land shall be from the nearest boundary of the ship or barge unit to the nearest fixed target.

C9.5.4. **Siting Criteria and Application of Q-D Separation Standards**

C9.5.4.1. **Maritime Prepositioning Ships (MPS)**

C9.5.4.1.1. Reduced Q-D criteria may be applied to those MPS that contain up to 1,300,000 pounds NEW of ammunition stored in standard ISO shipping containers.

C9.5.4.1.2. Inhabited building and public traffic route Q-D arcs for applicable MPS can be determined using K = 40.85 with a *3,700*-feet minimum fragment distance for inhabited building distance and K = 24.01 for public traffic route distance for MPS loads where no more than 52 percent of the NEW is Hazard Division 1.1 material. Above 52 percent, the K factor increases as shown in Table C9.T15., Columns 2 and 3. Table C9.T1. applies when the Hazard Division 1.1 material increases above 65 percent of the NEW.

C9.5.4.1.3. The Q-D arc between applicable MPS piers/anchorages and non-explosives loading piers/anchorages can be determined using K = 32 with a 3,500 feet minimum fragment distance for MPS loads where no more than 52 percent of the total NEW is Hazard Division 1.1 material. Above 52 percent, the K factor increases as shown in Table C9.T15., Column 4. Table C9.T16., Column 5 applies when the Hazard Division 1.1 material increases above 65 percent of the NEW.

Table C9.T15. Variation of MPS Q-D Factors with Loadout

Percent of Hazard Division 1.1	Inhabited Building Distance	Public Traffic Route	Ship-to-Ship
Up to 52	40.85	24.01	32.00
53	40.97	24.08	32.10
54	41.10	24.16	32.19
55	41.22	24.23	32.29
56	41.35	24.30	32.39
57	41.47	24.37	32.48
58	41.59	24.44	32.58
59	41.71	24.52	32.67
60	41.83	24.59	32.77
61	41.95	24.66	32.86
62	42.07	24.73	32.95
63	42.19	24.80	33.05
64	42.30	24.86	33.14
65	42.42	24.93	33.23

C9.5.4.2. **Scuttling Site**

C9.5.4.2.1. A properly located scuttling site shall be provided, if

practicable, for positioning a ship for its flooding or sinking in the event a vessel catches fire and must be moved to avert damage to other ships or piers. It shall have sufficient sea room and depth of water to permit the sinking of the largest vessel that may be handled at the installation so that the holds will be flooded completely at low water.

C9.5.4.2.2. Since an explosion may occur while the vessel is being moved, the location of the scuttling site shall provide the best available protection to other ships, piers, and shore installations.

C9.5.4.2.3. The location of the scuttling site will depend on the greatest net weight of mass-detonating explosives that may be in a single ship at any one time. The Q-D tables to be used will depend on the particular types of targets.

C9.5.4.3. **Explosives Anchorage.** The location of an explosives anchorage shall be separated not only from the main ship channel or from normally traversed routes of ships entering or leaving the harbor by column 9, Table C9.T1. distances, but also by turning circles and stopping distances of the ships. Assuming that the diameter of the turning circle of a ship is 1,000 yards, an explosives anchorage shall be located so that a ship in the channel will clear an anchored explosives-laden ship. From the turning circle standpoint, the separation distance shall be not less than 3,000 feet. Occasional watercraft passing through the arcs, while outside both the main ship channel and normally traversed routes of ships entering and leaving the harbor, are not subject to Q-D requirements.

C9.5.4.3.1. **Separation of Ships at Explosives Anchorages**

C9.5.4.3.1.1. When explosives anchorages are used for loading and unloading ships, as well as for fully loaded vessels anchored at their berths, ships that are being loaded or unloaded shall be separated from fully loaded ships.

C9.5.4.3.1.2. When the explosives anchorage is used only for loading and unloading ships, to prevent mass detonation, ships in the explosives anchorage shall be separated by at least $11W^{1/3}$ distances. Whenever possible, these separations distances shall be increased to $18W^{1/3}$ to reduce the loss potential of any incident.

C9.5.4.3.1.3. Loaded ships shall be separated one from another by at least $18W^{1/3}$ distances.

C9.5.4.3.2. **Separation of Explosives Anchorages From Other Targets**. Explosives anchorages shall be separated from explosives piers by $40W^{1/3}$ distances except when the anchorage is used only for the loading or unloading of vessels. In such cases, $18W^{1/3}$ distances may be used.

C9.5.4.4. **Separation Distances of Ship Units in Tandem at the Same Pier**

C9.5.4.4.1. Since the second ship would be in an area of heavy fragment

density from the exploding ship, it could be set afire and later caused to mass-detonate. A direct hit by a steel fragment on ammunition alongside the ship or in an open hold could also cause a mass-detonation. The separation distances based on blast damage alone, accordingly, are not enough to take care of such fragment hazards. Berthing of the two ships in tandem will help to decrease the fragment hazard to the explosives cargo of the second ship because of the additional protection afforded by the bow or stern.

C9.5.4.4.2. When two ships cannot be separated by $11W^{1/3}$ distances and are being loaded through all hatches, the spotting of railcars or trucks and the loading of hatches in both ships should be planned so as to put the greatest possible distance between open hatches of both ships, and between the trucks and railcars serving the two ships. When possible, the loading of the ships should be staggered.

C9.5.4.5. **Separation of Explosives Ships from Other Ships**. Explosives ships being loaded or unloaded shall be separated from nonexplosives-carrying ships and from loaded explosives ships that are not underway by $40W^{1/3}$ distances. Table C9.T1., column 9, distances shall be used for protection of ships that are underway.

(Approved change at 321st Board Meeting)

C9.5.4.6. Separation of Preposition Program Ships at Anchorages. The Military Sealift Command's Prepositioning Program (i.e. Combat Prepositioning Force, Maritime Prepositioning Force, Logistics Prepositioning Ships, etc.) operates both explosives-loaded and non-explosives carrying ships that are then deployed to key locations around the world. These ships are pre-loaded with military equipment and supplies necessary to support military forces on a short-notice basis and thus support a common mission. The following criteria applies to Prepositioning Program ships at anchorage:

C9.5.4.6.1. Non-explosives carrying ships shall be separated from explosives-loaded ships by a minimum of $18W^{1/3}$.

C9.5.4.6.2. Non-explosives carrying ships shall be separated from non-Prepositioning Program explosives-loaded ships by $40W^{1/3}$.

C9.5.4.6.3. Non-explosives carrying ships not associated with the Prepositioning Program shall be separated from all explosives carrying ships by $40W^{1/3}$.

C9.5.4.6.4. All non-explosives carrying ships shall be separated from explosives ships being loaded or unloaded by $40W^{1/3}$.

(Approved change at 320th Board Meeting)

*C9.5.4.7. **Barge Piers**. Piers and wharfs used exclusively for loading/unloading explosives on barges or utility craft may be sited from other shore facilities as loading docks, in accordance with paragraph C5.5.8. Shore facilities will be sited under the same criteria as Pier and Wharf Facilities, in relation to Barge Piers.*

C9.5.5. **Quantity-Distance Tables**. Figure C9.F2. shall be used in applying Table C9.T16. Q-D. Table C9.T1. Q-D shall be maintained between explosives pier and wharf facilities and such ESs as administration and industrial areas, terminal boundaries, main ship channels, and public traffic routes. As an ES, ship or barge units must be separated from explosives operating and storage facilities (including holding yards) by Table C9.T1., column 5, distances. As a PES, ship or barge units must be separated from explosives operating facilities by Table C9.T16., column 2, (barricaded) distances, and column 3 (unbarricaded), distances, as appropriate.

C9.5.6. **General Cargo and Vehicles at Ammunition Terminals**. Mission related general cargo, vehicles, and ammunition may be transferred through a terminal concurrently for the purpose of loading and/or offloading the same ship. Concurrent operations involving other ships shall be conducted at applicable quantity-distance separations. Separation of inert materials and equipment in holding areas shall be consistent with the requirements of Chapter 5, subsection C5.5.5. Personnel entering the inert holding areas shall be limited both in number and time of exposure. Any labor intense activity shall take place at applicable quantity-distance separation.

Table C9.T16. Quantity-Distance Separation for Pier and Wharf Facilities

Net Expl. Wt. (lb)	Distance in Feet			
	Hazard Factor (K)			
	6	11	18	40
1,000	60	110	180	400
1,200	64	117	191	425
1,500	69	126	206	458
1,900	74	136	223	495
2,500	81	149	244	543
3,100	87	160	262	583
3,900	94	173	283	630
5,000	103	188	308	684
6,300	111	203	332	739
7,900	119	219	358	797
10,000	129	237	388	862
12,000	137	252	412	916
15,000	148	271	444	986
19,000	160	294	480	1,067
25,000	175	322	526	1,170
31,000	188	346	565	1,257
39,000	203	373	610	1,356
50,000	221	405	663	1,474
63,000	239	438	716	1,592
79,000	257	472	772	1,716
100,000	278	511	835	1,857
120,000	296	543	888	1,973
150,000	319	584	956	2,125
190,000	345	632	1,035	2,300
250,000	378	693	1,134	2,520
310,000	406	744	1,218	2,707
390,000	438	804	1,315	2,922
500,000	476	873	1,429	3,175
630,000	514	943	1,543	3,429
790,000	555	1,017	1,664	3,698
1,000,000	600	1,100	1,800	4,000
1,200,000	638	1,169	1,913	4,251
1,500,000	687	1,259	2,060	4,579
1,900,000	743	1,362	2,229	4,954
2,500,000	814	1,493	2,443	5,429
3,100,000	875	1,604	2,625	5,832
3,900,000	944	1,731	2,833	6,296
5,000,000	1,026	1,881	3,078	6,840
6,300,000	1,108	2,032	3,324	7,388
7,900,000	1,195	2,191	3,585	7,967
10,000,000	1,293	2,370	3,878	8,618
12,000,000	1,374	2,518	4,121	9,158
15,000,000	1,480	2,713	4,439	9,865

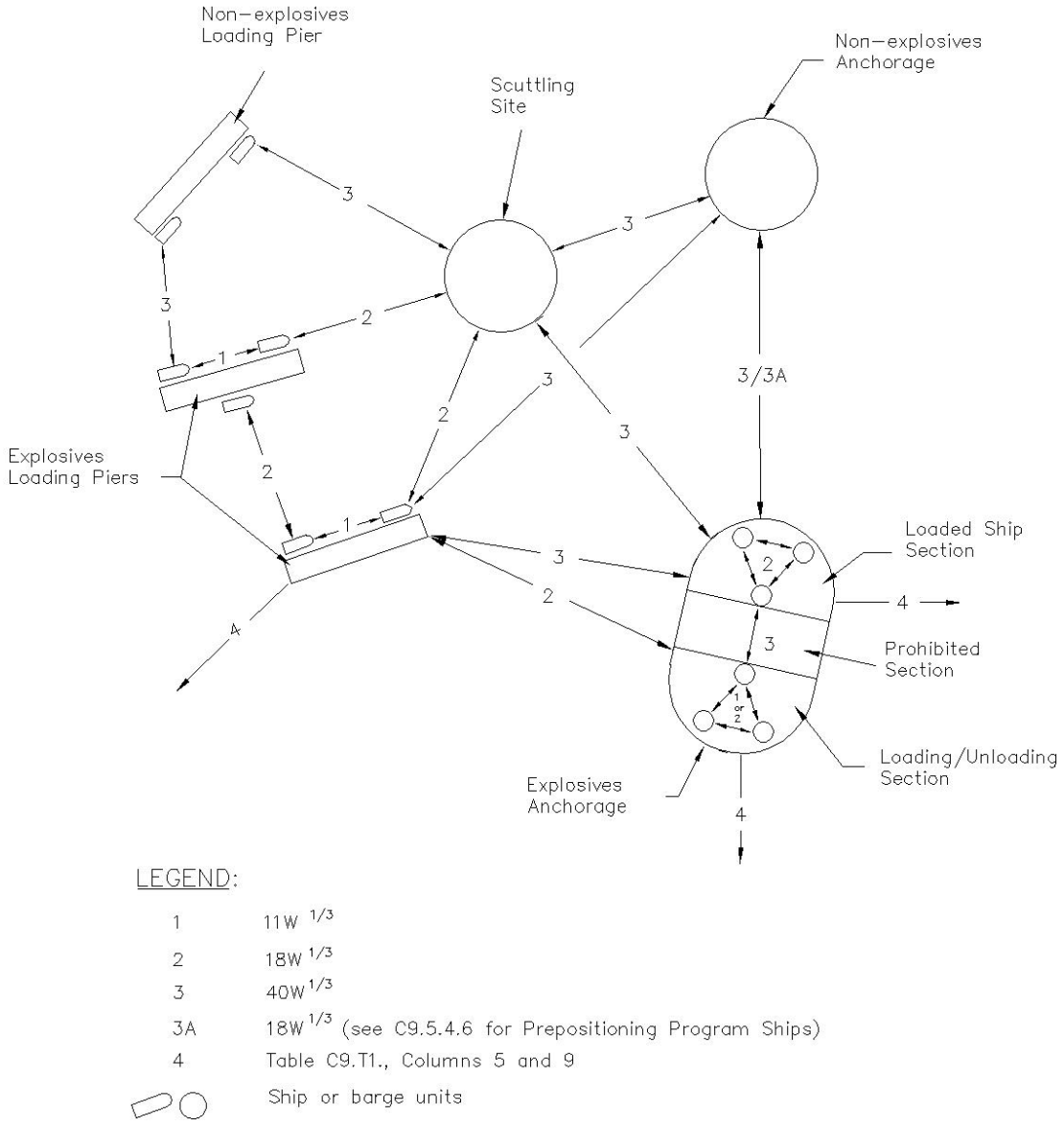


Figure C9.F2. Application of Separation Distances for Ship and Barge Units

(Approved correspondence 2 November 01)

C9.6. ENERGETIC LIQUIDS

C9.6.1. Scope and Application

C9.6.1.1. This section applies to the storage of energetic liquids (listed in Table C9.T17.) in all types of containers, including rocket and missile tankage. Laboratory Quantities shall be stored and handled as prescribed by the controlling Department of Defense (DoD) Component. (Note: The required quantity-distance (Q-D) are only based on the energetic liquids' energetic reaction (blast overpressure and container fragmentation). These Q-D requirements do not consider the toxicity or potential down-wind hazard. Therefore, Q-D may not be the only factor that needs to be considered when selecting a location for storage and operations of energetic liquids.)

C9.6.1.2. **Exclusion**. This section does not govern the storage or handling of energetic liquids for uses other than in space launch vehicles, rockets, missiles, associated static test apparatus, and ammunition items.

C9.6.2. Concept

C9.6.2.1. These Q-D standards were developed on the premise that the controlling DoD Component will ensure that the materials of construction are compatible with the energetic liquids, facilities are of appropriate design, fire protection and drainage control techniques are employed, and other specialized controls (such as nitrogen padding, blanketing, and tank cooling) are used when required.

C9.6.2.2. When additional hazards associated with ammunition or explosives are involved, the safety distances prescribed in other sections of this Chapter shall be applied, as appropriate.

C9.6.2.3. These standards are based upon the estimated credible damage resulting from an incident, without considering probabilities or frequency of occurrence.

C9.6.3. Determination of Energetic Liquids Quantity

C9.6.3.1. The total quantity of energetic liquids in a tank, drum, cylinder, or other container shall be the net weight of the energetic liquids contained therein. Quantity of energetic liquids in the associated piping must be included to the points that positive means are provided for interrupting the flow through the pipe, or interrupting a reaction in the pipe in the event of an incident.

C9.6.3.2. When the quantities of energetic liquids are given in gallons, the conversion factors given in Table C9.T18. may be used to determine the quantity in pounds.

C9.6.4. **Measurement of Separation Distances**

C9.6.4.1. Separation distances shall be measured from the closest hazard source (containers, buildings, segment, or positive cutoff point in piping, whichever is controlling).

C9.6.4.2. When buildings containing a small number of cylinders or drums are present or when quantities of energetic liquids are subdivided effectively, distances may be measured from the nearest container or controlling subdivision.

C9.6.5. **Hazard Classification of Energetic Liquids**. Replacement of the old Hazard Group (I - IV)/Compatibility Group (A - F) classification scheme (referenced in previous editions of DoD 6055.9-STD) for liquid propellants with United Nations (UN) hazard classification nomenclature as defined in Recommendations on the Transport of Dangerous Goods (Reference (d)) has been approved. Thus, the main hazard classification designator for energetic liquids is either Class 1 (explosives), Class 2 (compressed or liquefied gases), Class 3 (flammable liquids), Class 4 (flammable solids, self-reactive materials), Class 5 (oxidizers), Class 6 (toxic/infectious substances), Class 8 (corrosive), or Class 9 (miscellaneous). The design and logistics of modern weapons sometimes require that consideration be given to permitting storage or operations involving energetic liquids in a storage structure containing solid explosives. For example, it may be necessary to store hydrocarbon-fueled cruise missiles having high explosive warheads with fueled configurations not containing explosive warheads. Another example is the storage of liquid gun propellant with explosive ammunition components. Since two energetic liquids might each be compatible with certain explosive ammunition stores, but incompatible with each other, a two-part compatibility group designation is assigned to an energetic liquid.

C9.6.5.1. The first element is the standard storage and transportation Compatibility Group (CG) designation. The alpha designations are the same as the CG designations for UN Hazard Class 1, with the same definitions. However, for storage and handling on DoD facilities, a CG may also be assigned to an energetic liquid in a Hazard Class other than Class 1. The absence of a CG indicates incompatibility with solid explosives.

C9.6.5.2. The second element is a new Energetic Liquid Compatibility Group (ELCG) designation. The ELCG applies to mixed storage of energetic liquids or ammunition components containing energetic liquids. The ELCG is specified in parentheses as the last element of the hazard classification. The ELCG designations and definitions are:

LA - Energetic liquids that are strong oxidizers, mainly of acidic character. These materials may cause or contribute to the combustion of other material, possibly resulting in serious flare fires or explosions. Includes, but is not limited to, nitrogen tetroxide and mixed oxides of nitrogen (MON), inhibited red fuming nitric acid (IRFNA), liquid oxygen (LO_2), hydrogen peroxide (H_2O_2), and gels, slurries, or emulsions of the above.

LB - Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, but that are not strong reducing agents. Some

may be hypergolic with group LA materials. Includes, but is not limited to, hydrocarbons such as kerosene's and strained ring ramjet fuels; liquid hydrogen (LH_2); and gels, slurries, or emulsions of the above.

LC - Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, and are also strong reducing agents. These will likely be hypergolic with group LA substances. Includes, but is not limited to, hydrazine's and other amines; and gels, slurries, or emulsions of the above.

LD - Energetic liquids that act mainly as combustible fuels, similar to groups LB and LC, when exposed to, or ignited in the presence of oxidizing agents but that may act as oxidizers in some combinations. They may be a monopropellant with the right catalyst, or may be pyrophoric and ignite upon release to the atmosphere. Examples are ethylene and propylene oxides, and boranes.

LE - Energetic liquids having characteristics that do not permit storage with any other energetic liquid. They may react adversely with either fuels (reducing agents) or oxidizers. Examples are nitromethane, nitrate ester based formulations such as Otto Fuel II, liquid monopropellants containing hydroxyl ammonium nitrate (HAN), halogen fluorides (ClF_3 and ClF_5) and fluorine, and gels, slurries, or emulsions of the above.

C9.6.5.3. Different energetic liquids in the same ELCG may be stored together with the exception of dissimilar liquids of Group LE. Mixed storage is prohibited between energetic liquids of different ELCG designations, with one exception: liquids of groups LB and LC should not be stored together if possible, especially for storage areas containing primarily materials of group LB; however, mixed storage is permitted if circumstances require. This compatibility scheme is reflected in the hazard classification for the hydroxyl ammonium nitrate based liquid gun propellant XM-46:

1.3C(LE)

This hazard classification reflects CG "C" which indicates the propellant can be stored in the same magazine with CG "C" solid propellants, and since CG "C" can be mixed in storage with CG "D" (reference Table C3.T1., DoD 6055.9-STD), CG "D" high explosive projectiles could also be present. On the other hand, hydrocarbon fuel such as JP-10 would not be permitted in this storage scenario, because its ELCG (LB) indicates incompatibility with the liquid gun propellant (LE).

C9.6.5.4. Complete DoD hazard classification assignments for current energetic liquids are shown in Table C9.T17.

C9.6.5.5. Each new energetic liquid, or new non-bulk packaging configuration of an energetic liquid, developed by a DoD Component or adopted for DoD use, must be examined and assigned a hazard classification in accordance with the process described in Department of Defense Ammunition and Explosives Hazard Classification Procedures (reference (e)).

C9.6.5.6. The Q-D criteria described below include separation requirements for bulk quantities, and in some cases, minimum distances for pressure vessels and other commercial packaging. If the hazards of a particular new packaging configuration are not adequately addressed by the separations prescribed in the following tables, a different minimum distance may be assigned during the hazard classification process, and indicated parenthetically, in hundreds of feet, as the first element of the hazard classification. For example, if a new liquid oxidizer pressure vessel configuration is hazard classified: "(04)2.2(LA)," a minimum distance of 400 feet would apply for inhabited building distance and public traffic route distance, rather than the minimum distance specified in Table C9.T17.

C9.6.6. **Specific Hazardous Locations**. Aside from the fact that the energetic liquids differ from each other, as explained for the above groups, the predominant hazard of the individual energetic liquids can vary depending upon the location of the energetic liquid storage and the operations involved. In order of decreasing hazard, these conditions are:

C9.6.6.1. **Launch Pads**. These involve research, development, testing, space exploration, and operational launchings, as well as defense- or combat-type operations that may well be one-time events. Operations at these facilities are very hazardous because of the proximity of fuel and oxidizer to each other, the frequency of launchings, lack of restraint of the vehicle after liftoff, and the possibility of fallback with resultant dynamic mixing on impact. Launch vehicle tankage is involved and explosive equivalents must be used (Table C9.T19.) with the combined energetic liquids weight subject to mixing except as provided in paragraph C9.6.6.4., below.

C9.6.6.2. **Static Test Stands**. Although these can involve experimental operations, the units remain static and are subject to better control than launch vehicles. Except when run tankage for fuel and oxidizer are mounted one above the other, it may be possible to separate the tankage to reduce the hazard over that for the rocket or missile on the launch pad. Explosive equivalents shall be used (Table C9.T19.) with the combined energetic liquids weight subject to mixing as determined by hazard analysis. The amount of energetic liquids held in run tanks can be excluded from consideration if the test stand meets the following criteria:

C9.6.6.2.1. All tanks are American Society of Mechanical Engineers (ASME) certified (reference (ab)) and designed and maintained in accordance with section VIII division 1 or division 2 of the ASME Code.

C9.6.6.2.2. For cryogenic propellants, all tanks are constructed with double wall jacketing.

C9.6.6.2.3. The configuration of the test stand is such that the thrust Measuring structure load cell (heavily built structure) is between the engine and the run tanks so as to prevent fragments from puncturing the tanks in case of engine malfunction.

C9.6.6.2.4. Each feed line contains two remotely operated valves to shut off energetic liquids flow in the event of a malfunction.

C9.6.6.3. **Ready Storage**. This storage is relatively close to the launch and static test stands; normally it is not involved directly in feeding the engine as in the case with run tankage, which is an integral part of all launch and test stand operations. The explosive equivalents shall be used (Table C9.T19.) with the combined energetic liquids weight subject to mixing if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand, on the ground at the launch pad, or at the ready storage areas. Otherwise, fire and fragment hazards shall govern (Tables C9.T17., C9.T20., C9.T21., C9.T22., and C9.T23.).

C9.6.6.4. **Cold-flow Test Operations**. Fire and fragment hazards govern (Tables C9.T17., C9.T20., C9.T21., C9.T22., and C9.T23.) if the design is such that the system is closed except for approved venting, is completely airtight, fuel and oxidizer never are employed concurrently, and each has a completely separate isolated system and fitting types to preclude intermixing, and the energetic liquids are of required purity. Otherwise, explosive equivalents (Table C9.T19.) shall be used with the combined energetic liquids weight.

C9.6.6.5. **Bulk Storage**. This is the most remote storage with respect to launch and test operations. It consists of the area, tanks, and other containers therein, used to hold energetic liquids for supplying ready storage and, indirectly, run tankage where no ready storage is available. Fire and fragment hazards govern (Tables C9.T17., C9.T20., C9.T21., C9.T22., and C9.T23.) except in special cases as indicated in Tables C9.T17. and C9.T19.

C9.6.6.6. **Rest Storage**. This is temporary-type storage and most closely resembles bulk storage. It is a temporary parking location for barges, trailers, tank cars, and portable hold tanks used for topping operations when these units actually are not engaged in the operation; and for such vehicles when they are unable to empty their cargo promptly into the intended storage container. Fire and fragment hazards govern (Tables C9.T17., C9.T20., C9.T21., C9.T22., and C9.T23.) except in special cases as indicated in Tables C9.T17. and C9.T19. The transporter becomes a part of that storage to which it is connected during energetic liquids transfer.

C9.6.6.7. **Run Tankage (Operating Tankage).** This consists of the tank and other containers and associated piping used to hold the energetic liquids for direct feeding into the engine or device during operation. The contents of properly separated "run tanks" (operating tankage) and piping are normally considered on the basis of the pertinent hazards for the materials involved, except for quantities of incompatible materials that are or can be in a position to become mixed. HE equivalents shall be used (Table C9.T19.) for quantities of such materials subject to mixing unless provisions of paragraphs C9.6.6.2.1. through C9.6.6.2.4. are satisfied.

C9.6.6.8. **Pipelines**. A 25-foot clear zone to inhabited buildings shall be maintained, as a minimum, on each side of pipelines used for energetic liquids (excluding flammable or combustible liquids that exhibit normal fire hazards such as RP-1, JP-10, and Otto Fuel II). Tables C9.T17., C9.T21., C9.T22., and C9.T23. apply, as appropriate.

C9.6.7. **Q-D Standards**. Since many energetic liquids are not classified as UN Class 1 explosives, conventional Q-D storage criteria do not generally apply to these materials. At the same time, the (non-Class 1) UN transportation hazard classifications for many energetic liquids appear to be inappropriate and/or inadequate for application to storage safety (based on available accident and test data). For example, hydrazine has a UN hazard classification of 8 (corrosive), while it also is subject to dangerous fire and explosive behavior. Thus, the implementation of Q-D criteria for energetic liquids is based on an independent determination of the predominant hazard presented by the material in the storage environment. The following standards are applicable to energetic liquids used for propulsion or operation of missiles, rockets, and other related devices.

C9.6.7.1. Tables C9.T17., C9.T20., C9.T21., C9.T22., and C9.T23. provide minimum distance requirements for storage of bulk quantities, and in some cases, pressure vessels and other commercial packaging of energetic liquids. In general, storage of different energetic liquids shall be separated by the minimum distance required by the material requiring the greatest distance. In addition, positive measures shall be taken to control the flow of energetic liquids in the event of a leak or spill, in order to prevent possible fire propagation or accumulation of flammable liquids near other storage, and/or to prevent mixing of incompatible energetic liquids (except for specific hazardous locations as identified in Sections C9.6.6.1., C9.6.6.2., C9.6.6.3., and C9.6.6.7. above). Explosives equivalence applies for some materials as indicated in Tables C9.T17. and C9.T19. Fragment hazards govern for some materials in certain packaging configurations. For the more conventional fuels and oxidizers, and also where minimum blast and/or fragment criteria are not required due to low confinement packaging, Q-D standards are adopted from Occupational Safety and Health Administration (OSHA) and/or National Fire Protection Association (NFPA) guidelines to account for normal fire protection principles.

C9.6.7.2. For specific hazardous locations as defined in Paragraph C9.6.6. above, explosives equivalency may apply. If so, consult Tables C9.T17. and C9.T19. with the combined energetic liquids weight subject to mixing and use distances found in Tables C9.T1. or C9.T3. Enter weight of explosives equivalent in Tables C9.T1. or C9.T3. Q-D standards for other conditions and explosive equivalents for any combination not contained in Tables C9.T17. or C9.T19. shall be determined by the controlling DoD Component.

C9.6.8. **Contaminated Energetic Liquids**

C9.6.8.1. Caution shall be exercised in the storage and handling of contaminated energetic liquids. Such contamination may increase the degree of hazard associated with the energetic liquids.

C9.6.8.2. Energetic liquids known to be contaminated or in a suspect condition shall be isolated and provided separate storage from all other energetic liquids pending laboratory analysis for verification of contamination and disposition requirements, if any.

Table C9.T17. Hazard Classifications and Minimum Q-D for Energetic Liquids

Energetic Liquid	OSHA/NFPA Fuel[1] or Oxidizer[2] Class	DoD Storage Hazard Class	Minimum Q-D[3]
Hydrogen Peroxide, > 60%	3 or 4[4]	5.1 (LA)	800[5] ft or Table C9.T21.
IRFNA	3	8 (LA)	Table C9.T21.
Nitrogen Tetroxide/MON	2	2.3 (LA)	Table C9.T21.
Liquid Oxygen	N/A	2.2 (LA)	Table C9.T22.
RP-1	II	3 (LB)	Table C9.T20.
JP-10	II	3J (LB)	Table C9.T20.
Liquid Hydrogen	N/A	2.1 (LB)	Table C9.T23.
Hydrazine, > 64%	II	8 (LC)	800[5] or 300[6] ft or Note 7
Aerozine 50 (50%N_2H_4/50% UDMH)	I B	6.1 (LC)	800[5] or 300[6] ft or Note 7
Methylhydrazine	I B	6.1 (LC)	800[5] or 300[6] ft or Note 7
UDMH	I B	6.1 (LC)	Table C9.T20.
Ethylene Oxide	I A	2.3 (LD)	H/D 1.1 Q-D[8] with TNT Equiv = 100%, or 800[5] or 300[6] ft
Propylene Oxide	I A	3 (LD)	H/D 1.1 Q-D[8] with TNT Equiv. = 100%, or 800[5] or 300[6] ft
Nitromethane	I C	3 (LE)	Use H/D 1.1 Q-D with TNT Equiv. = 100%[9] or Table C9.T20.
Hydroxylammonium Nitrate (HAN)	2	8 (LE)	800[5] ft or Table C9.T21.
XM-46 (HAN Monopropellant)	N/A	1.3C (LE)	800[5] ft or use H/D 1.3 Q-D
Otto Fuel II	III B	9 (LE)	Use H/D 1.1 Q-D[10] with TNT Equiv. = 100%, or 150[11] ft, or Table C9.T20.
Halogen Fluorides (ClF_3/ClF_5)	4	2.3 (LE)	Table C9.T21.
Liquid Fluorine	4	2.3 (LE)	Table C9.T21.
Nitrogen Trifluoride	4	2.2 (LE)	Table C9.T21.
Nitrate esters (NG, TMETN, DEGDN, TEGDN, BTTN)	N/A	1.1 D (LE)	Use H/D 1.1 Q-D with TNT Equiv. = 100%

Notes:

1. Flammable or combustible liquid classification index based on flash point and boiling point versus criteria as specified in 29 CFR 1910.106 (OSHA) (Reference (ac)) and NFPA 30 Flammable and Combustible Liquids Code (Reference (j)). Primary descriptor is a Roman numeral, possibly with an additional letter.

2. NFPA oxidizer classification index as described in NFPA 430 Code for the Storage of Liquid and Solid Oxidizers (Reference (ad)). Descriptor is an ordinary number.

3. Positive measures for spill containment/control shall be taken for isolated storage of energetic liquids in accordance with applicable OSHA and NFPA guidance (referenced in Tables C9.T20. through C9.T22.). For flammable energetic liquids and liquid oxidizers where only minimum blast or fragment distances are specified, applicable OSHA and/or NFPA guidance referenced in Table C9.T20. through C9.T22., respectively, should also be used.

4. Hydrogen peroxide solutions of concentration greater than 91% are NFPA Class 4 oxidizers.

5. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small (non-bulk) shipping containers, portable ground support equipment, small aerospace flight vehicle propellant tanks, or similar pressure vessels that provide heavy confinement (burst pressure greater than 100 psi).

6. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small (non-bulk) shipping containers (DOT 5C or equivalent), portable ground support equipment, small aerospace flight vehicle propellant tanks, or similar pressure vessels providing a lower level of confinement (burst pressure less than or equal to 100 psi) and if adequate protection from fragments is not provided from terrain, effective barricades, nets, or other physical means (lightweight building construction is not adequate). If protection from fragments is provided, use the IBD/PTR Protected Distance column of Table C9.T23.

7. For large ready, bulk, or rest storage tanks (as defined in Paragraphs C9.6.6.3., C9.6.6.5., and C9.6.6.6.), use Table C9.T23.

8. Where there is a reasonable risk of vapor cloud explosion of large quantities (for example, in bulk tank storage).

9. Technical grade nitromethane in unit quantities of 55 gallons or less in DOT approved containers listed in 49CFR173.202 (reference (c)) may be stored as flammable liquids (Table C9.T20.) provided the following apply:

   a. Packages are stored only one tier high.

   b. Packages are protected from direct rays of sun.

   c. Maximum storage life of two years, unless storage life tests indicate product continues to meet purchase specifications. Such tests are to be replaced at one-year intervals thereafter.

10. For underwater static test stands, when operated at hydrostatic pressure above 50 psig, or for propellant tanks or other vessels having burst pressures of greater than 100 psig without acceptable pressure relief devices (unless otherwise hazard classified). For underwater test stands, the TNT equivalence (MCE) should include the total propellant weight in all pumps and plumbing, as well as the weight of propellant held in tankage (under the test cell hydrostatic pressure) unless acceptable mitigation measures such as fuel line detonation arrestors and/or fuel tank isolation/barricading are used (as determined by hazard analysis).

11. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small vehicle propellant tanks, small (non-bulk) shipping containers, portable ground support equipment, or similar pressure vessels that provide relatively heavy confinement (burst pressure between 50 – 100 psig) without acceptable pressure relief devices.

Table C9.T18. Factors to Use When Converting Gallons of Energetic Liquids into Pounds. [1]

Item	Pounds per gallon	At Temperature °F
Chlorine Pentafluoride	14.8	77
Chlorine trifluoride	15.1	77
Ethyl alcohol	6.6	68
Ethylene oxide	7.4	51
Fluorine (liquid)	12.6	-306
HAN Monopropellants	11.9	77
HAN solution (25 to 95 wt %)	10.0 to 13.4	68
Hydrazine	8.4	68
Hydrogen peroxide (90 percent)	11.6	77
JP-10	7.8	60
Liquid hydrogen	0.59	-423
Liquid oxygen	9.5	-297
Monomethyl hydrazine	7.3	68
Nitrogen tetroxide	12.1	68
Nitrogen trifluoride	12.8	-200
Nitromethane	9.5	68
Otto Fuel II	10.3	77
Propylene oxide	7.2	32
Red fuming nitric acid (IRFNA)	12.9	77
RP-1	6.8	68
UDMH	6.6	68
UDMH/hydrazine	7.5	77

1. Conversion of quantities of energetic liquids from gallons to pounds: Pounds of energetic liquids = gallons X density of energetic liquids in pounds per gallon.

Table C9.T19. Energetic Liquid Explosive Equivalents [1,2, 3, 4, 5]

ENERGETIC LIQUIDS	TNT EQUIVALENCE	
	STATIC TEST STANDS	RANGE LAUNCH
LO_2/LH_2	See Note 6	See Note 6
LO_2/LH_2 + LO_2/RP-1	Sum of (see Note 6 for LO_2/LH_2) + (10% for LO_2/RP-1)	Sum of (see Note 6 for LO_2/LH_2) + (20% for LO_2/RP-1)
LO_2/RP-1	10 %	20% up to 500,000 pounds plus 10% over 500,000 pounds
IRFNA/UDMH [7]	10%	10%
N_2O_4/UDMH + N_2H_4 [7]	5%	10%
N_2O_4 liquid oxidizer + PBAN solid fuel (Hybrid propellants)	15% [8]	15% [8]
Nitromethane (alone or in combination)	100%	100%
Otto Fuel II	100% [9]	
Ethylene Oxide	100% [10]	100% [10]

Notes:

1. The percentage factors given in the table are to be used to determine equivalencies of energetic liquids mixtures at static test stands and range launch pads when such energetic liquids are located aboveground and are unconfined except for their tankage. Other configurations shall be considered on an individual basis to determine equivalencies.

2. The explosives equivalent weight calculated by the use of this table shall be added to any non-nuclear explosive weight aboard before distances can be determined from Tables C9.T1. and C9.T3.

3. These equivalencies apply also for the following substitutions:

   a. Alcohol's or other hydrocarbons for RP-1.

   b. H_2O_2 for LO_2 (only when LO_2 is in combination with RP-1 or equivalent hydrocarbon fuel).

   c. MMH for N_2H_4, UDMH, or combinations of the two.

4. For quantities of energetic liquids up to but not over the equivalent of 100 pounds of explosives, the distance shall be determined on an individual basis by the DoD Component. All personnel and facilities, whether involved in the operation or not, shall be protected by operating procedures, equipment design, shielding, barricading, or other suitable means.

5. Distances less than intraline are not specified. Where a number of prepackaged energetic liquid units are stored together, separation distance to other storage facilities shall be determined on an individual basis by the DoD Component, taking into consideration normal hazard classification procedures.

6. For siting launch vehicles and static test stands, explosive equivalent weight is the larger of:

   (1) The weight equal to $8W^{2/3}$ where W is the weight of LO_2/LH_2, or

   (2) 14 percent of the LO_2/LH_2 weight.

   (NOTE: For these calculations, use the total weight of LO_2/LH_2 present in the launch vehicle, or the total weight in test stand run tankage and piping for which there is no positive means to prevent mixing in credible mishaps. When it can be reliably demonstrated that the maximum credible event involves a lesser quantity of energetic liquids subject to involvement in a single reaction, the lesser quantity may be used in determining the explosive equivalent yield. When siting is based on a quantity less than the total energetic liquids present, the maximum credible event and associated explosive yield analysis must be documented in an approved site plan (See C5.6))

7. These are hypergolic combinations.

8. Explosive equivalency of the hybrid rocket system N_2O_4 liquid oxidizer combined with PBAN solid fuel was evaluated in 200-pound tests (reference (ae)). These tests indicate a maximum TNT equivalency of 15% for an explosive donor accident scenario, 5% for a high velocity impact scenario, and less than 0.01% (negligible) for static mixing (tower drop) failures.

9. See Note 10 of Table C9.T17.

10. See Note 8 of Table C9.T17.

Table C9.T20. Q-D Criteria for OSHA/NFPA Class I – III Flammable and Combustible Energetic Liquids Storage in Detached Buildings or Tanks[1,2]

Quantity	IBD/PTR (ft)	ILD/Aboveground Intermagazine Distance (IMD) (ft)
Unlimited[3]	50 [4,5]	Note 6

Notes:

1. Other guidelines for diking, tank or container construction, tank venting, and facility construction apply (except for Class III B combustible liquids, e.g. Otto Fuel II). Refer to 29 CFR 1910.106 (reference (ac)) and NFPA 30 Flammable and Combustible Liquids Code (reference (j)) for further guidance on liquid storage and fire protection.

2. Refer to 29 CFR 1910.106 (reference (ac)) and NFPA 30 Flammable and Combustible Liquids Code (reference (j)) for definition and explanation of OSHA/NFPA classification of flammable and combustible liquids.

3. Guidelines on interior storage configuration (for container storage inside buildings) also apply with the following exceptions: (a) If the storage building is located at least 100 ft from any exposed building (under the direct jurisdiction of a fire protection organization) or property line; or (b) If the storage building is located at least 200 ft from any exposed building (not under the direct jurisdiction of a fire protection organization) or property line; or (c) for combustible liquids that will not exhibit sustained burning in bulk form, e.g. Otto Fuel II, as determined through ASTM D 92 Standard Test Method for Flash and Fire Points by Cleveland Open Cup or comparable testing. Refer to 29 CFR 1910.106 (reference (ac)) and NFPA 30 Flammable and Combustible Liquids Code (reference (j)) for further guidance on liquid storage and fire protection.

4. For container storage inside of a building, IBD/PTR distances may be less than 50 ft (to a minimum of 10 ft) if the storage building is constructed of fire resistive exterior walls having an NFPA Fire Resistance rating of two hours or more according to NFPA 251 (reference (af)).

5. For large tank storage, Q-D may be 25 feet for tank capacities up to 100,000 gallons, and 37.5 feet for capacities between 100,001 and 500,000 gallons.

6. For flammable liquids container storage inside of a building, ILD/Aboveground Intermagazine Distance (IMD) is 50 feet (accept as in Note 4), or for adjacent incompatible oxidizer storage, distances specified for energetic liquid oxidizers (Table C9.T21) or oxygen (Table C9.T22). For flammable liquids storage in fixed or large portable tanks, ILD/Aboveground IMD is either (1) for compatible energetic liquids, equal to one sixth of the sum of the diameters of the two adjacent tanks, or distances specified in Note 5 for adjacent container storage inside of a building; or (2) for adjacent incompatible oxidizer storage, distances specified for energetic liquid oxidizers (Table C9.T21) or oxygen (Table C9.T22) . Earth-covered magazines may be used to their physical capacity for storing flammable energetic liquids provided they comply with the construction and siting requirements of Chapter 5 and Chapter 9, respectively for Hazard Division 1.1. The earth-covered magazines must be sited for a minimum of 100 lbs of Hazard Division 1.1 items using Tables C9.T4. and C9.T5.

Table C9.T21. Q-D Criteria for Energetic Liquid Oxidizer (excluding Liquid Oxygen) Storage in Detached Buildings or Tanks[1, 2]

NFPA Oxidizer Class[3]	Quantity (lbs)	IBD/PTR/ILD/Aboveground IMD (ft)
2	up to 600,000	50
3	up to 400,000	75
4[4,5]	≤ 50	75
	70	76
	100	79
	150	84
	200	89
	300	98
	500	114
	700	128
	1,000	147
	1,500	175
	2,000 [6]	200
	3,000	246
	5,000	328
	7,000	404
	10,000	510
	15,000	592
	20,000	651
	30,000	746
	50,000	884
	70,000	989
	100,000	1114
	150,000	1275
	200,000	1404
	300,000	1607
	500,000	1905

Notes:

1. Quantity-distance requirements do not apply to storage of NFPA Class 2 and 3 oxidizers (reference (ad)) in approved fixed tanks.

2. Other requirements for interior storage configuration, building construction, diking, container materials, facility venting, etc. also apply. Refer to NFPA 430 Code for the Storage of Liquid and Solid Oxidizers (reference (ad)) for further guidance on oxidizer storage and fire protection.

3. Refer to NFPA 430 Code for the Storage of Liquid and Solid Oxidizers (reference (ad)) for definition and explanation of NFPA classification of oxidizers.

4. Multiple tanks containing NFPA Class 4 oxidizers may be located at distances less than those specified in the table; however, if the tanks are not separated from each other by 10 percent of the distance specified for the largest tank, then the total contents of all tanks shall be used to calculate distances to other exposures.

5. Notes for NFPA Oxidizer Class 4:

   (a) $W \leq 10{,}000$ lbs, Distance $= 149.3 * W^{(-0.41+0.059*\ln(W))}$

   (b) $W > 10{,}000$ lbs, Distance $= 24 * W^{1/3}$

(c) Use of equations given in (a) and (b) to determine distances for other quantities (W) is allowed.

6. NFPA 430 requires sprinkler protection to be provided for storage of greater than 2,000 pounds of NFPA Class 4 oxidizers inside of a building (reference (ad)).

Table C9.T22. Q-D Criteria for Liquid Oxygen Storage in Detached Buildings or Tanks [1,2]

	IBD/PTR (ft)	ILD/Aboveground IMD (ft)
Unlimited[3]	100	100 [4]

Notes:

1. Distances do not apply where a protective structure having an NFPA fire resistance rating of at least two hours according to NFPA 251 (reference (af)) interrupts the line of sight between the oxygen system and the exposure. Refer to 29 CFR 1910.104 (reference (ac)) and NFPA 50 Standard for Bulk Oxygen Systems at Consumer Sites (reference (ag)) for further guidance.

2. Additional guidelines relating to equipment assembly and installation, facility design (diking), and other fire protection issues also apply. Refer to 29 CFR 1910.104 (reference (ac)) and NFPA 50 Standard for Bulk Oxygen Systems at Consumer Sites (reference (ag)) for further guidance.

3. Q-D is independent of oxygen quantity.

4. Minimum ILD/IMD distance between adjacent compatible energetic liquids storage is 50 feet.

Table C9.T23. Q-D Criteria for Liquid Hydrogen and Bulk Quantities of Hydrazines[1]

Propellant Weight (pounds)	IBD/PTR		ILD/Aboveground IMD (ft) [6,7]
	Unprotected (ft)[2, 3]	Protected (ft) [4,5]	
0--100	600	80	30
200	600	100	37
300	600	113	42
400	600	122	46
500	600	130	49
600		136	51
700	600	141	53
800	600	145	54
900	600	149	56
1,000	600	153	57
2,000	600	176	66
3,000	600	191	72
4,000	600	202	76
	600	211	79
6,000	600	218	82
7,000	600	224	84
8,000	600	230	86
	600	235	88
10,000	603	239	90
15,000	691	258	97
	760	272	102
25,000	819	283	106
30,000	870	292	110
35,000	916	301	113
40,000	958	308	
45,000		315	118
50,000	1,032	321	120
60,000	1,096	332	
70,000		341	128
80,000	1,206	349	131
90,000	1,255	357	134
100,000	1,300	364	136
125,000	1,400	379	142
150,000	1,488	391	147
175,000	1,566	403	151

200,000	1,637	412	155
250,000	1,764	429	161
300,000	1,800	444	166
350,000	1,800	457	171
400,000	1,800	468	175
450,000	1,800	478	179
500,000	1,800	487	183
600,000	1,800	503	189
700,000	1,800	518	194
800,000	1,800	530	199
900,000	1,800	542	203
1,000,000[8]	1,800	552	207
	1,800	626	235
3,000,000	1,800	673	252
4,000,000	1,800	708	266
5,000,000	1,800	737	276
6,000,000	1,800	761	285
7,000,000	1,800	782	293
8,000,000	1,800	800	300
	1,800	817	306
	1,800	832	312

Notes:

1. Positive measures shall be taken to prevent mixing of hydrogen or hydrazine's and adjacent oxidizers in the event of a leak or spill.

2. Distances are necessary to provide reasonable protection from fragments of tanks or equipment that are expected to be thrown in event of a vapor phase explosion.

3. 10,000 $<W \leq$ 265,000 lbs, Unprotected Distance = $28*W^{1/3}$. Also W = $(\text{Unprotected Distance}/28)^3$.

4. The term "protected" means that protection from fragments is provided by terrain, effective barricades, nets, or other physical means.

5. Distances are based on the recommended inhabited building distances given in the Bureau of Mines, Department of the Interior Report No. 5707, dated 1961 (reference (ah)), and extrapolation thereof (2 cal/cm^2 on 1 percent water vapor curve). Curve fit of the data yields Protected Distance = $-154.1 + 72.89*[\ln(W)] - 6.675*[\ln(W)]^2 + 0.369*[\ln(W)]^3$.

Also W = $\exp[311.367 - 215.761*[\ln(\text{protected distance})] + 55.1828*[\ln(\text{protected distance})]^2 - 6.1099*[\ln(\text{protected distance})]^3 + 0.25343*[\ln(\text{protected distance})]^4]$.

6. ILD/Aboveground IMD distances in this column apply for adjacent compatible (ELCG LB or LC) storage; for adjacent incompatible (other ELCG) storage, use IBD distances shown in previous columns. Earth-covered magazines may be used to their physical capacity for storing hydrogen provided they comply with the construction and siting requirements of Chapter 5 and Chapter 9, respectively for Hazard Division 1.1. The earth-covered magazines must be sited for a minimum of 100 lbs of Hazard Division 1.1 items using Tables C9.T4 and C9.T5.

7. Distances are an average of 37.5 percent of "protected" column.

8. Extrapolations above 1,000,000 pounds extend well outside data included in reference (ah) from which the original Q-

D tables were derived; however, they are supported by independent calculations and knowledge of like phenomena

C9.7. UNDERGROUND STORAGE

C9.7.1. Scope

C9.7.1.1. This section details Q-D standards for the underground storage of military ammunition and explosives. Underground storage includes natural caverns and below grade, excavated chambers, but criteria of this section also apply to any storage facility providing the overpressure confinement effects typically encountered in underground storage. Use criteria of this section only when the minimum distance from the perimeter of a storage area to an exterior surface exceeds 0.25 $W^{1/3}$. Otherwise use aboveground siting criteria. This minimum distance most often, but not always, equals the thickness of the earth cover. This section addresses explosives safety criteria both with and without rupture of the earth cover.

C9.7.1.2. Expected ground shock, debris, and airblast hazards from an accidental explosion in an underground storage facility depend on several variables, including the local geology and site specific parameters. These parameters vary significantly from facility to facility, so criteria listed here will likely be safety conservative for some geologies and configurations. Siting distances other than those listed may be used when validated by approved experimental or analytical results showing equivalent protection to that required. Default, approved methods for establishing Q-D are discussed below.

C9.7.1.3. Q-D siting requirements of this section may be determined from the applicable equations or by interpolating between the table and figure entries.

C9.7.1.4. The provisions of this section do not apply to storage in earth-covered magazines described in Chapter 5 of this Standard.

C9.7.2. Design of Underground Storage Facilities

C9.7.2.1. Underground storage facilities may consist of a single chamber or a series of connected chambers. There may also be other protective construction features in the facility. The chamber(s) may be either excavated or natural geological cavities. Figure C9.F3. illustrates general concepts for several possible configurations of underground facilities.

C9.7.2.2. Design of new underground storage facilities must take into account site conditions, storage requirements and operational needs. Once these are established, a design may be developed based on Corps of Engineers definitive drawing number DEF 421-80-04.

C9.7.2.3. An underground storage site normally requires designed protection against lightning only for exposed or partially exposed parts. Metal and structural parts of the site that have less than 2 feet (60 cm) of earth cover shall be protected as for an aboveground site (see Chapter 7). Lightning protection requirements must be considered on a site specific basis.

C9.7.3. Explosion Effects in Underground Storage Site

C9.7.3.1. Confinement caused by the very limited space in underground storage will cause very high pressures of prolonged duration from an accidental explosion. Blast waves and dynamic flow fields will travel at high velocity throughout the underground facility. Ground shocks will be produced, and breakup of the earth cover with attendant debris throw may occur.

C9.7.3.2. Under conditions of heavy confinement and high loading density Hazard Division 1.3 material may, while either detonating or burning, produce intense gas pressures sufficient to rupture the earth cover and create a significant debris hazard.

C9.7.3.3. An accidental explosion involving only Hazard Division 1.2 material will likely start a fire that is sustained by burning packages and other ammunition. This may cause further explosions that become more frequent as the fires build and multiply until everything in the site is destroyed. Results of these repeated explosions will depend on the type and quantity of munitions, the type of explosion produced, and the layout of the facility. Hazards created outside the underground facility will likely not be as severe as those produced by Hazard Division 1.1 or 1.3 material.

C9.7.4. **Protection Provided.** Q-D criteria listed here provide separation distances from stored ammunition and explosives to mitigate the hazards caused by ground shock, debris, or air blast. The required distance for a given quantity and storage condition is that corresponding to the dominant (farthest-reaching) hazard that is applicable to the exposure under consideration. It is therefore the largest of the distances determined to be necessary for protection against the individual effects considered in turn.

C9.7.5. **Chamber Separation Requirements**

C9.7.5.1. Minimum storage chamber separation distances are required to prevent or control the communication of explosions or fires between donor and acceptor chambers. There are three modes by which an explosion or fire can be communicated: by rock spall, by propagation through cracks or fissures, and by airblast or thermal effects traveling through connecting passages.

C9.7.5.2. **Prevention of Damage by Rock Spall (Hazard Divisions 1.1 and 1.3).** The chamber separation distance is the shortest distance (rock thickness) between two chambers. When an explosion occurs in a donor chamber, a shock wave is transmitted through the surrounding rock. The intensity of the shock decreases with distance. For small chamber separation distances, the shock may be strong enough to produce spalling of the rock walls of acceptor chambers. Spalled rock of sufficient mass, traveling with a sufficient velocity, may damage or sympathetically detonate impacted munitions in the acceptor chambers. When no specific protective construction is used, the minimum chamber separation distance, D_{cd} required to prevent hazardous spall effects is:

$$D_{cd} = 2.5 \bullet W^{1/3} \qquad (9\text{-}1)$$

Where D_{cd} is in feet and W is in pounds. D_{cd}, in no case, shall be less than 15 feet.

The separation distances defined above applies to chamber loading densities up to 3.0 pounds per cubic foot, as determined from table C9.T24. and moderate to strong rock types. This loading density is the basis for values of D_{cd} listed in table C9.T25. For greater loading densities in moderate to strong rock, the required separation distance is:

$$D_{cd} = 5.0 \bullet W^{1/3} \qquad (9\text{-}2)$$

For weak rock, at all loading densities, the separation distance is:

$$D_{cd} = 3.5 \bullet W^{1/3} \qquad (9\text{-}3)$$

C9.7.5.3. **Prevention of Propagation by Rock Spall (Hazard Divisions 1.1 and 1.3).** If damage to stored munitions in the adjacent chambers is acceptable, the chamber separation distance can be reduced to the distance required to prevent propagation of the detonation by the impact of rock spall against the munitions. This is considered an immediate mode of propagation because time separations between donor and acceptor explosions may not be sufficient to prevent coalescence of blastwaves. Unless analyses or experiments indicate otherwise, explosives weights subject to this mode must be added to other donor explosives weights to determine NEW. When no special protective construction is used, the separation distance, D_{cp}, to prevent explosion communication by spalled rock is:

$$D_{cp} = 1.5 \bullet W^{1/3} \qquad (9\text{-}4)$$

Where D_{cp} is in feet and W is in pounds.

When the acceptor chamber has protective construction to prevent spall and collapse (into the acceptor chamber) the separation distance to prevent propagation by impact of spalled rock is:

$$D_{cp} = 0.75 \bullet W^{1/3} \qquad (9\text{-}5)$$

D_{cp} is in feet and W is the weight in pounds of Hazard Divisions 1.1 and 1.3 material in the donor chamber. Separation distances, D_{cp} and D_{cd}, are listed in table C9.T25. These distances are based on an explosive loading density of about 17 lb/ft^3. The distances will likely be safety conservative for lower loading densities but the effects have not been quantified.

C9.7.5.4. **Prevention of Propagation Through Cracks and Fissures (Hazard Divisions 1.1 and 1.3).** Propagation between a donor and acceptor chamber has been observed to occur when natural, near horizontal jointing planes, cracks or fissures in the rock between the chambers are opened by the lifting force of the detonation pressure in the donor chamber. Prior to construction of a multi-chamber magazine, a careful site investigation must be made to ensure that such joints or fissures do not extend from one chamber location to an adjacent one. Should such defects be encountered during facility excavation, a reevaluation of the intended siting will be required.

C9.7.5.5. **Prevention of Propagation through Passageways (Hazard Divisions**

1.1 and 1.3). Flame and hot gas may cause delayed propagation. Time separations between the original donor event and the potential explosions of this mode will likely be sufficient to prevent coalescence of blastwaves. Consequently, for purposes of Q-D siting, only the maximum credible explosives weight need be used to determine NEW. In order to protect assets, blast and fire resistant doors must be installed within multi-chambered facilities. Evaluations for required chamber separations due to this communication mode should be made on a site specific basis using procedures outlined in Corps of Engineers definitive drawing DEF 421-80-04.

C9.7.5.6. For Hazard Divisions 1.1 and 1.3 materials, chamber entrances at the ground surface, or entrances to branch tunnels off the same side of a main passageway, shall be separated by at least 15 feet (5 meters). Entrances to branch tunnels off opposite sides of a main passageway shall be separated by at least twice the width of the main passageway.

C9.7.5.7. Chambers, containing only Hazard Divisions 1.2 and 1.4 material and separated by the appropriate distance listed above, may be used to the limits of their physical capacities except for any items having special stacking and NEW restrictions. However, when Hazard Division 1.2 or 1.4 material is stored in the same chamber with Hazard Division 1.1 or 1.3 material, the propellant and explosive content of all hazard divisions material shall be added to obtain NEW.

C9.7.6. **Critical Chamber Cover Thickness.** The chamber cover thickness is the shortest distance between the natural rock surface at the chamber ceiling (or in some cases, a chamber wall) and the ground surface. The critical cover thickness required to prevent breaching of the chamber cover by a detonation is $2.5W^{1/3}$ for all types of rock.

C9.7.7. **External Q-D Determinations**

C9.7.7.1. **Hazard Division Material Dependence**

C9.7.7.1.1. **Hazard Division 1.1 and 1.3 Materials**. Distances shall be determined from the total quantity of explosives, propellants, pyrotechnics, and incendiary materials in the individual chambers, unless the total quantity is subdivided to prevent rapid communication of an incident from one subdivision to another (see subsection C9.2.2., above). All Hazard Divisions 1.1 and/or 1.3 material subject to involvement in a single incident shall be assumed to contribute to the explosion yield as would an equal weight of TNT. Any significant and validated differences in energy release per unit mass of the compositions involved from that of TNT may be considered. A connected chamber or cavern storage site containing Hazard Division 1.1 or 1.3 material shall be treated as a single chamber site, unless explosion communication is prevented by adequate subdivision or chamber separation.

C9.7.7.1.2. **Hazard Division 1.2 Materials.** Except for primary fragments from openings to underground storage, external explosives safety hazards are not normally significant for Hazard Division 1.2 materials. The safe distance for both IBD and PTR is the IBD distance in tables C9.T6. through C9.T9. for locations within ± 10 degrees of the centerline of a tunnel opening. These default criteria apply only to those detonations which occur where a line-of-sight path exists from the detonation point to any portion of the tunnel

opening. For detonations which do not have a line-of-sight path to the tunnel opening, or where the line-of-sight path is intercepted by a barricade beyond the opening, the IBD and PTR hazard distances are zero.

C9.7.7.1.3. **Hazard Division 1.4 Materials.** External explosives safety hazards are not normally significant for Hazard Division 1.4 materials. Accordingly, external Q-D criteria do not apply for Hazard Division 1.4 materials.

C9.7.7.2. **Q-D Reference Points**

C9.7.7.2.1. Distances determined by blast or debris issuing from tunnel openings shall be the minimum distance measured from the openings to the nearest wall or point of the location to be protected. Use extended centerlines of the openings as reference lines for directional effects.

C9.7.7.2.2. Distances determined for airblast and debris produced by breaching of the chamber cover shall be the minimum distance from an exterior point defined by chamber cover thickness, on the ground surface above the storage chamber to the nearest wall or point of the location to be protected. For configurations where the storage chambers are not distinct from the access tunnel**,** the distance is the shortest distance from the tunnel roof directly above the charge to the surface.

C9.7.7.2.3. Distances determined for ground shock shall be the minimum distance measured from the nearest wall of the storage chamber to the location to be protected.

C9.7.7.3. **Inhabited Building Distance (Hazard Divisions 1.1 and 1.3 Materials)**. Inhabited building distances shall be the largest of those distances required for protection against ground shock, debris, and airblast as defined below.

C9.7.7.3.1. **Ground Shock**

C9.7.7.3.1.1. For protection of residential buildings against significant structural damage by ground shock, the maximum particle velocity induced in the ground at the building site may not exceed the following values, which form the basis for the equations in subparagraph *C9.7.7.3.1.2.*, below:

2.4 ips in soil,

4.5 ips in weak rock, and

9.0 ips in strong rock.

C9.7.7.3.1.2. For sitings in moderately strong to strong rock with chamber loading densities of 3.0 lbs/ft^3 (50 kg/m^3) or less, the IBD for ground shock, D_{ig} is:

$$D_{ig} = 5.8 \bullet W^{1/3} \qquad (9\text{-}6a)$$

Where D_{ig} is in feet and W is the explosive quantity in pounds.

For higher loading densities in chambers sited in moderately strong to strong rock, and for all loading densities in other materials, the IBD for ground shock is:

$$D_{ig} = 12.5 \bullet f_g \bullet W^{4/9} \text{ (Moderately strong to strong rock)} \quad (9\text{-}6b)$$

$$D_{ig} = 11.1 \bullet f_g \bullet W^{4/9} \text{ (Weak rock)} \quad (9\text{-}6c)$$

$$D_{ig} = 2.1 \bullet f_g \bullet W^{4/9} \text{ (Soil)} \quad (9\text{-}6d)$$

Values of D_{ig}/f_g are shown in table C9.T26. The dimensionless, decoupling factor, f_g depends on chamber loading density, w, and is:

$$f_g = (4/15) \bullet\bullet w^{0.3} \quad (9\text{-}7)$$

Values of f_g are shown in table C9.T27. Chamber loading density is the NEW (in pounds) divided by the volume of the storage chamber, V_c (in cubic feet). Alternate values for D_{ig} may be used only when justified by site specific ground shock data.

C9.7.7.3.2. **Debris**

C9.7.7.3.2.1. A minimum IBD distance of 1800 feet (550 meters) for debris throw from an opening shall apply within ±10 degrees to either side of the centerline axis of that opening unless positive means are used to prevent or control the debris throw.

C9.7.7.3.2.2. Distances required for protection of inhabited areas against the effects of debris D_{id} thrown from breaching of the cover material over a detonation depend on the thickness of the cover, C, over the storage chamber. Siting criteria for debris from a surface breach need not be considered for chamber cover thicknesses greater than the critical value, C_c, of $2.5 \bullet W^{1/3}$. If the cover thickness is less than C_c, the distance, D_{id}, will be calculated from $D_{id} = f_d \bullet f_c \bullet W^{0.41}$, where $f_d = 0.6 \bullet w^{0.18}$, and f_c is a constant related to the type of rock around the storage chamber.

C9.7.7.3.2.3. Values of D_{id}/f_d, for hard (moderately strong to strong) rock and for weak rock, are listed in tables C9.T28. and C9.T29., respectively. Values of f_c are shown graphically in Figure C9.F4. Values for the decoupling factors f_g and f_d are listed in table C9.T27.

C9.7.7.3.2.4. Special features may be incorporated in the design of underground facilities to reduce the IBD for debris ejected through tunnel openings.

C9.7.7.3.2.4.1. Debris traps are pockets excavated in the rock at or beyond the end of sections of tunnel, designed to catch debris from a storage chamber detonation. Debris traps should be at least 20 percent wider and 10 percent taller than the tunnel

leading to the trap, with a depth (measured along the shortest wall) of at least one tunnel diameter.

C9.7.7.3.2.4.2. Expansion chambers are very effective in entrapping debris, as long as the tunnels entering and exiting the chambers are either offset in axial alignment by at least two tunnel widths, or enter and exit the chambers in directions that differ by at least 45 degrees.

C9.7.7.3.2.4.3. Portal barricades provide a means of reducing IBD from debris by obstructing the path of the debris as it exits the tunnel. Construction and location requirements for barricades are contained in section C5.3., Chapter 5.

C9.7.7.3.2.4.4. High-pressure closures are large blocks constructed of concrete or other materials, that can obstruct or greatly reduce the flow of blast effects and debris from an explosion, from or into a storage chamber. For chamber loading densities of about 0.625 lb/ft^3 or above, closure blocks will contain 40 percent or more of the explosion debris within the detonation chamber, provided that the block is designed to remain intact. If a closure block fails under the blast load, it will produce a volume of debris in addition to that from the chamber itself. However, since the block's mass and inertia are sufficient to greatly reduce the velocity of the primary debris, the effectiveness of other debris-mitigating features, such as debris traps, expansion chambers, and barricades is increased.

C9.7.7.3.2.5. Debris traps, and expansion chambers intended to entrap debris, must be designed to contain the full potential volume of debris, based on the maximum capacity of the largest storage chamber. Design specifications for debris traps, expansion chambers, closure blocks and portal barricades are given in Corps of Engineers definitive drawing number DEF 421-80-04.

C9.7.7.3.2.6. Use of barricades in conjunction with any other of these features will lower the debris hazard to a level where Q-D considerations for debris will not be required.

C9.7.7.3.3. **Airblast**

C9.7.7.3.3.1. An explosion in an underground storage chamber may produce external airblast from two sources; the exit of blast from existing openings (tunnel entrances, ventilation shafts, etc.) and the rupture or breach of the chamber cover by the detonation. Required inhabited building distances are to be independently determined for each of these airblast sources, with the maximum IBD used for siting. If the chamber cover thickness is less than the critical thickness, C_c, given in subsection C9.7.6., above, some amount of external airblast will be produced, depending on the cover thickness. Use the following procedure to find IBD for airblast produced by breaching of the chamber cover:

$C \leq 0.25W^{1/3}$: Use IBD for surface burst of bare explosives charge (Table C9.T1., Note 3)

$0.25W^{1/3} < C \leq 0.50W^{1/3}$: Use 1/2 of IBD for surface burst of bare explosives charge

$0.50W^{1/3} < C \leq 0.75W^{1/3}$: Use 1/4 of IBD for surface burst of bare explosives charge

$0.75W^{1/3} < C$: Airblast hazards from blast through the earth cover are negligible relative to ground shock or debris hazards.

C9.7.7.3.3.2. Overpressure and debris hazards must be determined for each facility opening whose cross-section area is five percent or more of that of the largest opening.

C9.7.7.3.3.3. Distance vs overpressure along the centerline axis of a single opening is:

$$R = 149.3 \bullet D_{HYD} \bullet ((W/V_E)^{0.5}/p_{SO})^{1/1.4} \qquad (9\text{-}8a)$$

where:

R: distance from opening (feet),

D_{HYD}: effective hydraulic diameter that controls dynamic flow issuing from the opening (feet) (Compute D, using the minimum, cross-sectional area of the tunnel that is located within five tunnel diameters of the opening, as $D = 4 \bullet A/P$, where A is the area and P is the perimeter.),

P_{SO}: overpressure at distance R (psi).

W: maximum credible event (MCE) in pounds

V_E: Total volume engulfed by the blast wavefront within the tunnel system at the time the wavefront arrives at the point of interest (ft^3)

C9.7.7.3.3.4. Distance vs overpressure off the centerline axis of the opening is:

$$R(\theta) = R(\theta=0)/(1 + (\theta/56)^2)^{1/1.4} \qquad (9\text{-}8b)$$

where:

$R(\theta = 0)$ is the distance along the centerline axis, and θ is the horizontal angle from the centerline (degrees).

C9.7.7.3.3.5. Equations 9-8a and 9-8b show that the distance providing protection from an overpressure exceeding P_{SO} depends on the hydraulic diameter, and the angle from the centerline axis for the location of interest. Figure C9.F5. shows the ratio of off-axis to on-axis distances.

C9.7.7.3.3.6. Find required IBD distances for airblast using the appropriate equations discussed above, with the criteria that the total incident overpressure at IBD shall not exceed:

P_{SO} = 1.2 psi for W < 100,000 lbs, (9-9a)
$P_{SO} = 44.57 \bullet W^{-0.314}$ psi for 100,000 ≤ W ≤ 250,000 lbs, (9-9b)
P_{SO} = 0.9 psi for W > 250,000 lbs. (9-9c)

C9.7.7.3.3.7. For the overpressures of Equations 9-9a to 9-9c, on-axis IBD distances are:

$R = 131.1 \bullet D_{HYD} \bullet (W/V_E)^{1/2.8}$ for W < 100,000 lbs, (9-10a)
$R = 9.91 \bullet D_{HYD} \bullet W^{0.581}/V_E^{0.357}$ for 100,000 W ≤ 250,000 lbs, (9-10b)
$R = 161.0 \bullet D_{HYD} \bullet (W/V_E)^{1/2.8}$ for W > 250,000 lbs, (9-10c)

C9.7.7.3.3.8. Q-D distances for IBD for airblast may be determined from the equations listed above or from entries in tables C9.T30. and C9.T31.

C9.7.7.3.4. **Airblast Mitigation Methods for Reducing IBD.** Special features that may be incorporated in underground storage facilities to reduce the airblast IBD include:

C9.7.7.3.4.1. **Facility Layouts.** A single-chamber facility with a straight access tunnel leading from the chamber to the portal is commonly called a "shotgun" magazine because the blast and debris are channeled to the external area as if fired from a long-barreled gun. More complex facility layouts will provide some reductions in the exit pressures due to reflections of the explosive shock against the tunnel walls. The cumulative effect is to reduce the overpressure at the shock front to the point that the peak overpressure is produced by the detonation gas flow following the front. The detonation gas pressure decreases as the volume it occupies increases. Therefore, the peak overpressure produced at the tunnel opening will also decrease with an increase in the total volume of the tunnels and chambers that can be filled by the blast as it travels from the detonation source (e.g., a storage chamber) to the opening, as given in the previous section. Larger facilities will, therefore, produce greater reductions in the effective overpressure at the opening, which will, in turn, reduce the IBD. The IBD should be reduced by 10 percent when two or more openings of similar cross-sectional area exist.

C9.7.7.3.4.2. **Expansion Chambers.** Expansion chambers are so-named because of the volume they provide for the expansion of the detonation gasses behind the shock front as it enters the chamber from a connecting tunnel. Some additional degradation of the peak pressure at the shock front occurs as the front expands into the chamber and reflects from the walls. The principal benefit provided by an expansion chamber, however, is simply the added volume which decreases pressures. Expansion chambers also have practical purposes. They may be used as loading/unloading chambers, providing weather protection for the transfer of munitions from trucks to materials handling equipment prior to placement in storage chambers, or as turn-around areas for transport vehicles servicing facilities through a single entry passage.

C9.7.7.3.4.3. **Constrictions.** Constrictions are short

lengths of tunnel whose cross-sectional areas are reduced to one-half or less of the normal tunnel cross-section. The use of constrictions should be limited to locations within 5 tunnel diameters of the tunnel exit or to the entrances of storage chambers. A constriction near the tunnel exit, where the overpressure has dropped near a minimum value in the tunnel, defines the hydraulic diameter to be used in Equation 9-8a. The purpose of a constriction at a chamber entrance is to reduce the intrusion of airblast and thermal effects into the chamber from a detonation in an adjacent chamber. A constricted chamber entrance also reduces the area, and hence the total loading on a blast door installed to protect the chamber contents.

C9.7.7.3.4.4. **Portal Barricades.** For most underground storage facilities, the airblast from a storage chamber detonation that exits a tunnel portal will be in the form of a shock wave. It will expand in all directions from the portal in a manner similar to that from a detonation at the portal. A barricade in front of the portal will reflect that portion of the shock wave moving directly outward from the portal. By reflecting this portion of the total airblast, the pressures along the extended tunnel axis are reduced, and the pressures in the opposite direction, behind the portal are increased. The result is a more circular IBD area centered at the portal. Since much of the blast is also reflected upward, the total IBD area is less than would occur without a barricade. For cases where the blast must travel a large distance from the storage chamber to the portal, with several changes in direction along the travel path, the airblast exiting the portal may primarily consist of a strong, highly-directional gas flow. A barricade will intercept such a flow and deflect it in directions 90 degrees from the tunnel axis. Whether the blast exiting the portal is shock or gas flow-dominated, the barricade must be located within certain minimum and maximum standoff distances to be effective. For the barricade design recommended in subsection C5.3.5., Chapter 5, these limits are one to three tunnel diameters (at the portal). Portal barricades reduce the IBD along the extended tunnel axis by 50 percent. The total IBD area is only slightly reduced, but will change to a circular area, half of which is behind the portal. The barricade should be constructed as described in subsection C5.3.5., Chapter 5 and Corps of Engineers definitive drawing number DEF 421-80-04.

C9.7.7.3.4.5. **High-Pressure Closures**

C9.7.7.3.4.5.1. High Pressure Closures are large blocks constructed of concrete or other materials, that can obstruct or greatly reduce the flow of blast effects and debris from an explosion, from or into a storage chamber. If used to provide complete protection to the contents of a chamber from an explosion in another chamber, the block must be designed to move from a normally-closed position to an open position to allow entry into the chamber. Blast doors are not required for this type of closure block. If used to reduce Q-D by restricting the blast outflow from a chamber, the block must be designed to be rapidly driven from an open to a closed position by the detonation pressures in the chamber. While this type of block will provide some protection of chamber contents from an explosion in another chamber, blast doors must also be used to provide complete protection. Tests have shown that a closure block with sufficient mass can obstruct the initial outflow of airblast from an explosion in a chamber to reduce pressures in the connecting tunnels by a factor of two or more, even when the block is destroyed. Blocks with sufficient strength to remain structurally intact can provide greater reductions. Since many variables influence the performance of a closing device, their design details must be developed on a site-specific basis.

C9.7.7.3.4.5.2. A 50% reduction in IBD should be applied to a high pressure closure block provided that the block is designed to remain intact in the event of an explosion. This reduction is applicable for loading densities of 0.625 lb/ft^3 or higher. For loading densities lower than 0.625 lb/ft^3 (but greater than 0.0625 lb/ft^3), reductions may be calculated by the formula:

$$y(\%) = 50 \bullet \log_{10}(16.02 \bullet w) \qquad (9\text{-}11)$$

where y is the percent reduction in IBD, and w is loading density in lb/ft^3. For loading densities lower than 0.0625 lb/ft^3; y(%) = 0.

Closure block design criteria are found in Corps of Engineers definitive design drawing number DEF 421-80-04.

C9.7.7.4. **Public Traffic Route (PTR) Distance (Hazard Divisions 1.1 and 1.3 Materials)**

C9.7.7.4.1. **Ground Shock.** Q-D is 60 percent of IBD for ground shock.

C9.7.7.4.2. **Debris.** Q-D is 60 percent of IBD for debris.

C9.7.7.4.3. **Airblast.** Q-D is 60 percent of IBD for airblast.

C9.7.7.5. **Intraline Distance (Hazard Divisions 1.1 And 1.3 Materials)**

C9.7.7.5.1. **Ground Shock.** Q-D criteria for ground shock do not apply.

C9.7.7.5.2. **Debris.** For locations within ±10 degrees of the centerline of a tunnel opening, site intraline facilities at IBD for debris issuing from the opening, calculated as directed in subparagraph C9.7.7.3.2., above. Q-D criteria for debris are not applicable for locations greater than ±10 degrees from the centerline axis of an opening.

C9.7.7.5.3. **Airblast.** Overpressure at barricaded and unbarricaded intraline distances shall not exceed 12 and 3.5 psi, respectively.

C9.7.7.6. **Distance to Aboveground Magazines (Hazard Divisions 1.1 and 1.3 Materials)**

C9.7.7.6.1. **Ground Shock.** Q-D criteria for ground shock do not apply.

C9.7.7.6.2. **Debris.** For locations within ±10 degrees of the centerline of an opening, site aboveground magazines at IBD, for that debris issuing from the opening, in accordance with subparagraph C9.7.7.3.2., above. Q-D criteria for debris from rupture of the chamber cover do not apply.

C9.7.7.6.3. **Airblast.** Overpressure at barricaded and unbarricaded

aboveground magazine distance shall not exceed 27 and 8 psi, respectively.

C9.7.7.7. **Distance to Earth-Covered Aboveground Magazines (Hazard Divisions 1.1 and 1.3 Materials)**

C9.7.7.7.1. **Ground Shock.** Q-D criteria for ground shock do not apply.

C9.7.7.7.2. **Debris.** Q-D criteria for debris from rupture of the chamber cover do not apply. Q-D criteria for debris issuing from an opening do not apply if the magazine is oriented for side-on or rear-on exposures to the debris but the criteria do apply for frontal exposures. Site earth-covered magazines that are located within ±10 degrees of the centerline of an opening and oriented for a frontal debris exposure at IBD for that debris hazard calculated as directed in subparagraph C9.7.7.3.2. above.

C9.7.7.7.3. **Airblast.** These sitings are based on the strength of the earth-covered magazines (ECM) under consideration and utilize side-on overpressures calculated from Equations 9-8a and 9-8b.

C9.7.7.7.3.1. **Head-On Exposure**

C9.7.7.7.3.1.1. 7-Bar ECM: Site where the side-on overpressure, p_{SO}, is 29 psi.

C9.7.7.7.3.1.2. 3-Bar ECM: Site where the side-on overpressure, p_{SO}, is 16 psi.

C9.7.7.7.3.1.3. Undefined ECM: Site where the side-on overpressure, p_{SO}, is 3.5 psi.

C9.7.7.7.3.2. **Other Than Head-On Exposure**. Site all ECMs where side-on overpressure, p_{SO}, is 45 psi.

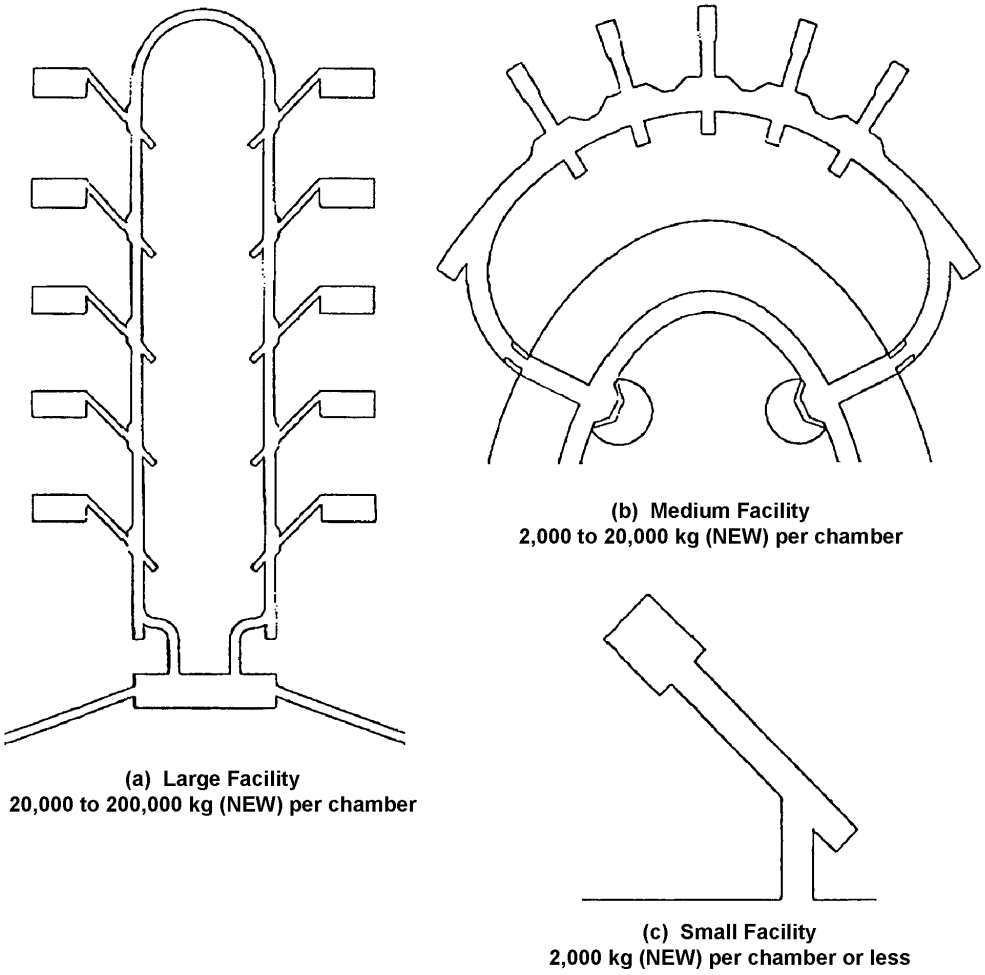


Figure C9.F3. Typical Underground Facilities

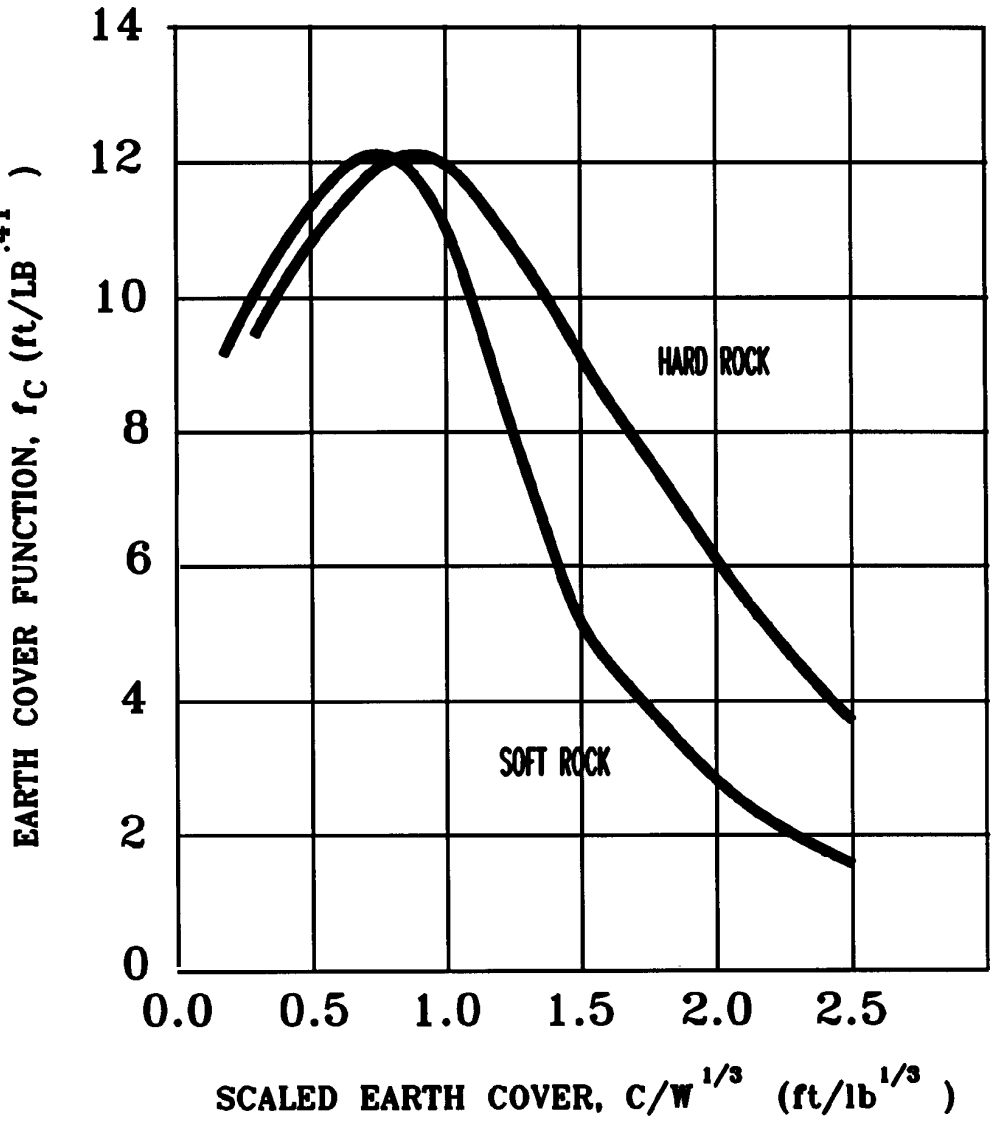


Figure C9.F4. Debris Dispersal Functions

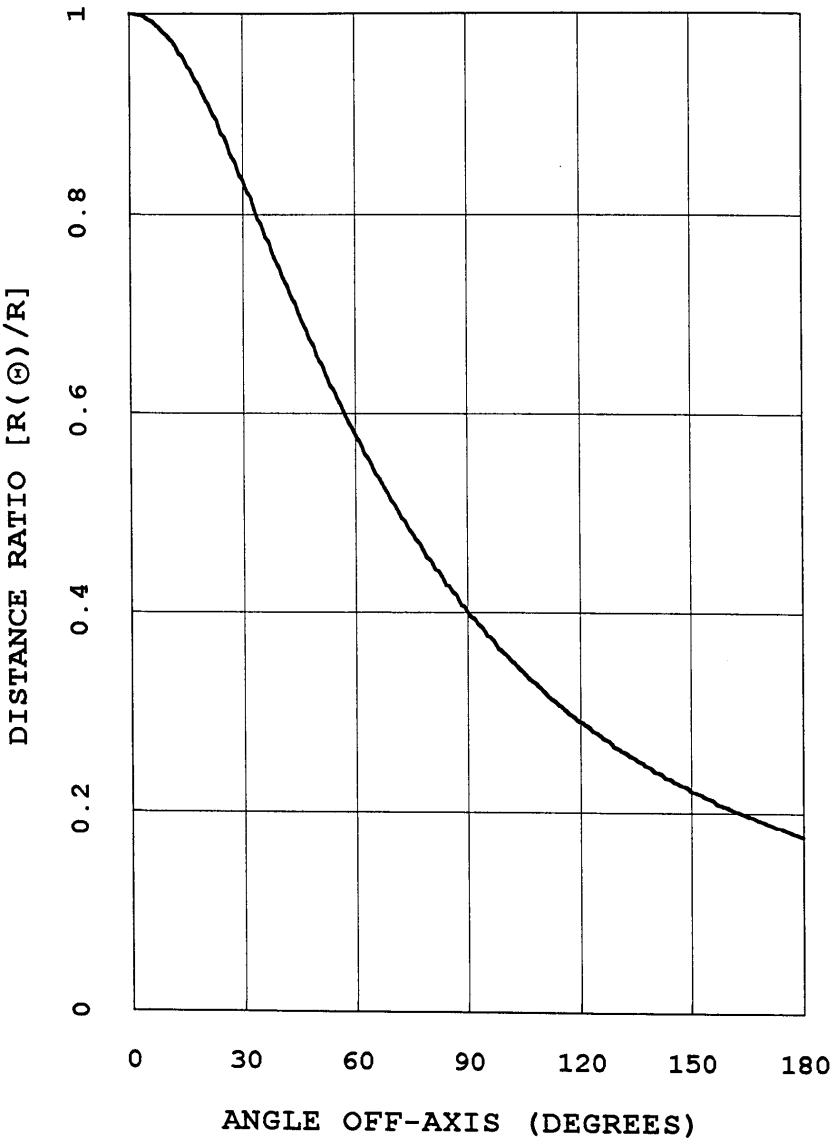


Figure C9.F5. Constant Pressure Contour

Table C9.T24. Chamber Loading Density (w)

NEW (lbs)	Chamber Volume (ft^3)							
	2,000	5,000	10,000	20,000	30,000	50,000	75,000	100,000
1,000	0.500	0.200	0.100	0.050	0.033	0.020	0.013	0.010
1,200	0.600	0.240	0.120	0.060	0.040	0.024	0.016	0.012
1,400	0.700	0.280	0.140	0.070	0.047	0.028	0.019	0.014
1,600	0.800	0.320	0.160	0.080	0.053	0.032	0.021	0.016
1,800	0.900	0.360	0.180	0.090	0.060	0.036	0.024	0.018
2,000	1.000	0.400	0.200	0.100	0.067	0.040	0.027	0.020
2,500	1.250	0.500	0.250	0.125	0.083	0.050	0.033	0.025
3,000	1.500	0.600	0.300	0.150	0.100	0.060	0.040	0.030
3,500	1.750	0.700	0.350	0.175	0.117	0.070	0.047	0.035
4,000	2.000	0.800	0.400	0.200	0.133	0.080	0.053	0.040
5,000	2.500	1.000	0.500	0.250	0.167	0.100	0.067	0.050
6,000	3.000	1.200	0.600	0.300	0.200	0.120	0.080	0.060
7,000	3.500	1.400	0.700	0.350	0.233	0.140	0.093	0.070
8,000	4.000	1.600	0.800	0.400	0.267	0.160	0.107	0.080
9,000	4.500	1.800	0.900	0.450	0.300	0.180	0.120	0.090
10,000	5.000	2.000	1.000	0.500	0.333	0.200	0.133	0.100
12,000	6.000	2.400	1.200	0.600	0.400	0.240	0.160	0.120
14,000	7.000	2.800	1.400	0.700	0.467	0.280	0.187	0.140
16,000	8.000	3.200	1.600	0.800	0.533	0.320	0.213	0.160
18,000	9.000	3.600	1.800	0.900	0.600	0.360	0.240	0.180
20,000	10.000	4.000	2.000	1.000	0.667	0.400	0.267	0.200
25,000	12.500	5.000	2.500	1.250	0.833	0.500	0.333	0.250
30,000	15.000	6.000	3.000	1.500	1.000	0.600	0.400	0.300
35,000	17.500	7.000	3.500	1.750	1.167	0.700	0.467	0.350
40,000	20.000	8.000	4.000	2.000	1.333	0.800	0.533	0.400
45,000	22.500	9.000	4.500	2.250	1.500	0.900	0.600	0.450
50,000	25.000	10.000	5.000	2.500	1.667	1.000	0.667	0.500
60,000	30.000	12.000	6.000	3.000	2.000	1.200	0.800	0.600
70,000	35.000	14.000	7.000	3.500	2.333	1.400	0.933	0.700
80,000	40.000	16.000	8.000	4.000	2.667	1.600	1.067	0.800
90,000	45.000	18.000	9.000	4.500	3.000	1.800	1.200	0.900
100,000	50.000	20.000	10.000	5.000	3.333	2.000	1.333	1.000
120,000	60.000	24.000	12.000	6.000	4.000	2.400	1.600	1.200
140,000	70.000	28.000	14.000	7.000	4.667	2.800	1.867	1.400
160,000	80.000	32.000	16.000	8.000	5.333	3.200	2.133	1.600
180,000	90.000	36.000	18.000	9.000	6.000	3.600	2.400	1.800
200,000	100.000	40.000	20.000	10.000	6.667	4.000	2.667	2.000
300,000	150.000	60.000	30.000	15.000	10.000	6.000	4.000	3.000
400,000	200.000	80.000	40.000	20.000	13.333	8.000	5.333	4.000
500,000	250.000	100.000	50.000	25.000	16.667	10.000	6.667	5.000
600,000	300.000	120.000	60.000	30.000	20.000	12.000	8.000	6.000
700,000	350.000	140.000	70.000	35.000	23.333	14.000	9.333	7.000
800,000	400.000	160.000	80.000	40.000	26.667	16.000	10.667	8.000
900,000	450.000	180.000	90.000	45.000	30.000	18.000	12.000	9.000
1,000,000	500.000	200.000	100.000	50.000	33.333	20.000	13.333	10.000

Table C9.T25. Chamber Separation

Weight (lbs)	D_{cp} (ft)	D_{cd} (ft)		
	$1.5W^{1/3}$	$2.5W^{1/3}$	$3.5W^{1/3}$	$5.0W^{1/3}$
1,000	15	25	35	50
1,200	16	27	37	53
1,400	17	28	39	56
1,600	17.5	29	41	58
1,800	18	30	43	61
2,000	19	31	44	63
2,500	20.4	34	48	68
3,000	22	36	50	72
3,500	23	38	53	76
4,000	24	40	56	79
4,500	25	41	58	83
5,000	26	43	60	85
6,000	27	45	64	91
7,000	29	48	67	96
8,000	30	50	70	100
9,000	31	52	73	104
19,000	40	67	93	133
12,000	34	57	80	114
14,000	36	60	84	121
16,000	38	63	88	126
18,000	39	66	92	131
20,000	41	68	95	136
25,000	44	73	102	146
30,000	47	78	109	155
35,000	49	82	114	164
40,000	51	85	120	171
45,000	53	89	124	178
50,000	55	92	129	184
60,000	59	98	137	196
70,000	62	103	144	206
80,000	65	108	151	215
90,000	67	112	157	224
100,000	70	116	162	232
120,000	74	123	173	247
140,000	78	130	182	260
160,000	81	136	190	271
180,000	85	141	198	282
200,000	88	146	205	292
250,000	94	157	220	315
300,000	100	167	234	335
350,000	106	176	247	352
400,000	111	184	258	368
450,000	115	192	268	383
500,000	119	198	278	397
600,000	127	211	295	422
700,000	133	222	311	444
800,000	139	232	325	464
900,000	145	241	338	483

1,000,000	150	250	350	500

Table C9.T26. Distances to Protect Against Ground Shock

Weight(lbs)	$2.1W^{4/9}$	D_{ig}/f_g $11.1W^{4/9}$	$12.5W^{4/9}$	D_{ig} $5.8W^{1/3}$
1,000	45	239	269	58
1,200	49	259	292	62
1,400	53	278	313	65
1,600	56	295	332	68
1,800	59	311	350	71
2,000	62	325	366	73
2,500	68	359	405	79
3,000	74	390	439	84
3,500	79	417	470	88
4,000	84	443	499	92
4,500	88	467	525	96
5,000	93	489	551	99
6,000	100	530	597	105
7,000	107	568	640	111
8,000	114	603	679	116
9,000	120	635	715	121
10,000	126	665	749	125
12,000	137	722	813	133
14,000	146	773	870	140
16,000	155	820	923	146
18,000	163	864	973	152
20,000	171	906	1,020	157
25,000	189	1,000	1,126	170
30,000	205	1,084	1,221	180
35,000	220	1,161	1,308	190
40,000	233	1,232	1,388	198
45,000	246	1,298	1,462	206
50,000	257	1,361	1,532	214
60,000	279	1,476	1,662	227
70,000	299	1,580	1,779	239
80,000	317	1,677	1,888	250
90,000	334	1,767	1,990	260
100,000	350	1,852	2,085	269
120,000	380	2,008	2,261	286
140,000	407	2,150	2,421	301
160,000	432	2,282	2,570	315
180,000	455	2,404	2,708	327
200,000	477	2,520	2,837	339
250,000	526	2,782	3,133	365
300,000	571	3,017	3,398	388
350,000	611	3,231	3,639	409
400,000	649	3,429	3,861	427
450,000	684	3,613	4,069	444
500,000	716	3,786	4,264	460
600,000	777	4,106	4,624	489
700,000	832	4,397	4,951	515
800,000	883	4,666	5,254	538
900,000	930	4,916	5,537	560

Table C9.T27. Functions of Loading Density

Loading Density w (lbs/ft^3)	Ground Shock f_g ($0.267\ w^{0.30}$)	Debris f_d ($0.600\ w^{0.18}$)
1.0	0.27	0.60
1.2	0.28	0.62
1.4	0.30	0.64
1.6	0.31	0.65
1.8	0.32	0.67
2.0	0.33	0.68
2.5	0.35	0.71
3.0	0.37	0.73
3.5	0.39	0.75
4.0	0.40	0.77
4.5	0.42	0.79
5.0	0.43	0.80
6.0	0.46	0.83
7.0	0.48	0.85
8.0	0.50	0.87
9.0	0.52	0.89
10.0	0.53	0.91
12.0	0.56	0.94
14.0	0.59	0.96
16.0	0.61	0.99
18.0	0.64	1.01
20.0	0.66	1.03
25.0	0.70	1.07
30.0	0.74	1.11
35.0	0.78	1.14
40.0	0.81	1.17
45.0	0.84	1.19
50.0	0.86	1.21
60.0	0.91	1.25
70.0	0.96	1.29
80.0	0.99	1.32
90.0	1.03	1.35
100.0	1.06	1.37

Table C9.T28. Distances to Protect Against Hard Rock Debris

Weight (lbs)	$C/W^{1/3}$ ($ft/lb^{1/3}$)							
	0.3	0.5	0.7	0.9	1.1	1.6	2.1	3
	D_{id}/f_d (ft)							
1000	163	180	200	205	195	145	92	62
1200	170	195	215	220	210	155	98	67
1400	185	210	230	235	225	165	105	72
1600	195	220	240	250	240	175	110	76
1800	205	230	250	260	250	180	115	79
2000	210	240	260	270	260	190	120	83
2500	230	260	290	300	290	210	135	91
3000	250	290	310	320	310	225	145	98
3500	270	300	330	340	330	240	155	105
4000	280	320	350	360	350	250	160	110
4500	300	340	370	380	360	260	170	115
5000	310	350	380	400	380	280	175	120
6000	330	380	410	430	410	300	190	130
7000	350	400	440	460	440	320	205	140
8000	370	430	470	480	460	330	215	145
9000	390	450	490	500	480	350	225	155
10000	410	470	520	520	500	370	235	160
12000	440	500	560	560	540	400	250	175
14000	470	540	580	600	580	420	270	185
16000	500	560	620	640	620	440	290	195
18000	520	600	640	680	640	470	300	205
20000	540	620	680	700	680	490	310	215
25000	600	680	740	760	740	540	340	235
30000	640	740	800	820	800	580	370	250
35000	680	780	860	880	840	620	390	270
40000	720	820	900	940	900	640	420	285
45000	760	860	940	980	940	680	440	295
50000	800	900	980	1000	980	700	460	310
60000	860	980	1050	1100	1050	760	490	335
70000	920	1050	1150	1150	1100	820	520	355
80000	960	1100	1200	1250	1100	860	560	375
90000	1000	1150	1250	1300	1250	900	580	395
100000	1050	1200	1300	1350	1300	940	600	410
120000	1150	1300	1400	1450	1400	1000	660	445
140000	1200	1400	1500	1550	1500	1100	700	475
160000	1300	1450	1600	1650	1600	1150	740	500
180000	1350	1550	1650	1750	1650	1200	780	525
200000	1400	1600	1750	1800	1750	1250	800	550
250000	1550	1750	1900	2000	1900	1350	880	600
300000	1650	1900	2050	2150	1500	1500	960	645
350000	1750	2000	2200	2250	2200	1600	1000	690
400000	1850	2100	2300	2400	2300	1650	1050	725
450000	1950	2200	2450	2500	2400	1750	1100	765
500000	2050	2300	2500	2600	2500	1800	1150	800
600000	2200	2500	2700	2800	2700	1950	1250	860
700000	2350	2700	2900	3000	2900	2100	1350	915
800000	2450	2800	3100	3200	3100	2200	1400	965
900000	2600	3000	3200	3300	3200	2300	1500	1015

Table C9.T29. Distances to Protect Against Soft Rock Debris

Weight (lbs)	$C/W^{1/3}$ ($ft/lb^{1/3}$)							
	0.2	0.6	0.75	0.9	1	1.5	1.75	2.5
	D_{id}/f_d (ft)							
1,000	165	200	207	198	184	91	62	30
1,200	177	216	223	213	199	98	67	32
1,400	189	230	238	227	212	105	72	34
1,600	200	243	251	240	224	110	76	36
1,800	210	255	264	252	235	116	79	38
2,000	219	266	275	263	245	121	83	40
2,500	240	292	302	288	268	133	91	43
3,000	258	314	325	311	289	143	98	47
3,500	275	335	346	331	308	152	104	50
4,000	291	354	366	350	326	161	110	53
4,500	305	371	384	367	342	169	116	55
5,000	319	388	401	383	357	176	121	58
6,000	343	418	432	413	384	190	130	62
7,000	366	445	460	440	409	202	139	66
8,000	386	470	486	464	433	214	147	70
9,000	405	493	510	487	454	224	154	74
10,000	423	515	532	509	474	234	161	77
12,000	456	555	574	548	511	252	173	83
14,000	486	591	611	584	544	269	184	88
16,000	513	624	645	617	575	284	195	93
18,000	539	655	677	648	603	298	204	98
20,000	562	684	707	676	630	311	213	102
25,000	616	750	775	741	690	341	234	112
30,000	664	808	835	798	744	367	252	120
35,000	707	861	890	851	792	391	268	128
40,000	747	909	940	898	837	413	283	136
45,000	784	954	986	943	878	434	297	142
50,000	819	996	1,030	985	917	453	311	148
60,000	882	1,074	1,110	1,061	988	488	335	160
70,000	940	1,144	1,182	1,130	1,053	520	357	170
80,000	993	1,208	1,249	1,194	1,112	549	377	180
90,000	1,042	1,268	1,311	1,253	1,167	576	395	189
100,000	1,088	1,324	1,368	1,308	1,218	602	413	197
120,000	1,172	1,426	1,475	1,410	1,313	648	445	213
140,000	1,249	1,520	1,571	1,502	1,399	691	474	226
160,000	1,319	1,605	1,659	1,586	1,477	730	500	239
180,000	1,384	1,684	1,741	1,665	1,550	766	525	251
200,000	1,445	1,759	1,818	1,738	1,619	800	548	262
250,000	1,584	1,927	1,992	1,905	1,774	876	601	287
300,000	1,707	2,077	2,147	2,052	1,911	944	648	310
350,000	1,818	2,212	2,287	2,186	2,036	1,006	690	330
400,000	1,921	2,337	2,416	2,309	2,151	1,062	729	348
450,000	2,016	2,453	2,535	2,424	2,257	1,115	765	366
500,000	2,105	2,561	2,647	2,531	2,357	1,164	798	382
600,000	2,268	2,760	2,853	2,727	2,540	1,254	860	411
700,000	2,416	2,940	3,039	2,905	2,705	1,336	917	438
800,000	2,552	3,105	3,210	3,068	2,858	1,412	968	463
900,000	2,678	3,259	3,369	3,220	2,999	1,481	1,016	486

Table C9.T30. Values for Ratio, $D_{HYD}/V_E^{1/2.8}$

V_E (ft^3)	$D_{HYD}/V_E^{1/2.8}$ Effective Hydraulic Diameter, D_{HYD} (ft)					
	10	15	20	25	30	35
1,000	0.8483	1.2725	1.6967	2.1209	2.5450	2.9692
2,000	0.6623	0.9935	1.3246	1.6558	1.9869	2.3181
3,000	0.5730	0.8595	1.1460	1.4326	1.7191	2.0056
4,000	0.5171	0.7756	1.0341	1.2927	1.5512	1.8097
5,000	0.4775	0.7162	0.9549	1.1937	1.4324	1.6711
6,000	0.4474	0.6710	0.8947	1.1184	1.3421	1.5658
7,000	0.4234	0.6351	0.8468	1.0585	1.2702	1.4819
8,000	0.4037	0.6055	0.8074	1.0092	1.2110	1.4129
9,000	0.3871	0.5806	0.7741	0.9676	1.1612	1.3547
10,000	0.3728	0.5591	0.7455	0.9319	1.1183	1.3047
20,000	0.2910	0.4365	0.5820	0.7275	0.8731	1.0186
30,000	0.2518	0.3777	0.5036	0.6295	0.7554	0.8812
40,000	0.2272	0.3408	0.4544	0.5680	0.6816	0.7952
50,000	0.2098	0.3147	0.4196	0.5245	0.6294	0.7343
60,000	0.1966	0.2949	0.3931	0.4914	0.5897	0.6880
70,000	0.1860	0.2791	0.3721	0.4651	0.5581	0.6511
80,000	0.1774	0.2661	0.3548	0.4434	0.5321	0.6208
90,000	0.1701	0.2551	0.3401	0.4252	0.5102	0.5952
100,000	0.1638	0.2457	0.3276	0.4095	0.4914	0.5733
200,000	0.1279	0.1918	0.2557	0.3197	0.3836	0.4476
300,000	0.1106	0.1660	0.2213	0.2766	0.3319	0.3872
400,000	0.0998	0.1497	0.1997	0.2496	0.2995	0.3494
500,000	0.0922	0.1383	0.1844	0.2305	0.2766	0.3226
600,000	0.0864	0.1296	0.1727	0.2159	0.2591	0.3023
700,000	0.0817	0.1226	0.1635	0.2044	0.2452	0.2861
800,000	0.0779	0.1169	0.1559	0.1948	0.2338	0.2728
900,000	0.0747	0.1121	0.1495	0.1868	0.2242	0.2615
1,000,000	0.0720	0.1080	0.1439	0.1799	0.2159	0.2519
2,000,000	0.0562	0.0843	0.1124	0.1405	0.1686	0.1967
3,000,000	0.0486	0.0729	0.0972	0.1215	0.1458	0.1701
4,000,000	0.0439	0.0658	0.0877	0.1097	0.1316	0.1535
5,000,000	0.0405	0.0608	0.0810	0.1013	0.1215	0.1418

Table C9.T31. Scaled IBD for Airblast without Mitigating Devices[1,2,3]

NEW (lbs)	$R(\theta)/(D_{HYD}/V_E^{1/2.8})$ Horizontal Angle from Centerline Axis (Degrees)					
	0	30	60	90	120	180
1,000	1,545	1,290	895	621	452	273
2,000	1,979	1,653	1,146	795	579	349
3,000	2,287	1,910	1,325	919	669	404
4,000	2,535	2,117	1,468	1,019	741	448
5,000	2,745	2,292	1,590	1,103	803	485
7,000	3,096	2,585	1,793	1,244	905	547
10,000	3,516	2,936	2,037	1,413	1,028	621
20,000	4,504	3,761	2,609	1,810	1,317	795
30,000	5,206	4,347	3,015	2,092	1,522	919
40,000	5,769	4,818	3,341	2,319	1,687	1,019
50,000	6,247	5,217	3,619	2,511	1,827	1,103
70,000	7,045	5,883	4,081	2,831	2,060	1,244
100,000	8,002	6,683	4,635	3,216	2,340	1,413
200,000	11,977	10,002	6,937	4,813	3,502	2,115
250,000	13,633	11,384	7,896	5,479	3,987	2,407
500,000	17,462	14,582	10,114	7,018	5,106	3,083
700,000	19,691	16,444	11,406	7,914	5,759	3,477
1,000,000	22,367	18,678	12,955	8,989	6,541	3,949
2,000,000	28,649	23,925	16,594	11,514	8,378	5,059
3,000,000	33,113	27,652	19,180	13,308	9,684	5,847
5,000,000	39,740	33,187	23,018	15,972	11,622	7,017
7,000,000	44,815	37,424	25,957	18,011	13,106	7,913
10,000,000	50,903	42,509	29,484	20,458	14,886	8,988

1. IBD for airblast without airblast mitigating devices:
   $R(\theta)/(D_{HYD}/V_E^{1/1.4}) = 149.3 \bullet \{W^{0.5}/[p_{SO}(1+(\theta/56)^2)]\}^{1/1.4}$ (English Units)
   where: $p_{SO} = 1.2$ psi — $W \le 100{,}000$ lbs
   $p_{SO} = 44.57 \bullet W^{-0.314}$ psi — $100{,}000 \le W \le 250{,}000$ lbs
   $p_{SO} = 0.9$ psi — $W > 250{,}000$ lbs
2. Reduce IBD by 50% when portal barricade configured IAW COE Definitive Drawing 421-80-04 is used.
3. Reduce IBD as follows when a closure plug designed IAW COE Definitive Drawing 421-80-04 is used:
   Reduction (%) = 0 % — $w \le 0.0625$ lb/ft^3
   Reduction (%) = $50 \log_{10}(16.02 \bullet w)$ — $0.0625 < w \le 0.625$ lb/ft^3
   Reduction (%) = 50% — $w > 0.625$ lb/ft^3

C9.8. **MILITARY WORKING DOG EXPLOSIVES SEARCH TRAINING**

C9.8.1. **General.** Realistic and effective training of military working dogs (MWD) involves simulated searches to detect explosives that have been hidden in various public places. These training operations typically include handling explosives, cutting or dividing explosive training aids, removing explosives from the shipping and storage containers, and repackaging explosives into other containers. For these reasons, training operations shall be conducted by qualified personnel only in facilities that meet the Q-D and other requirements of this Standard.

C9.8.2. **Requirements.** The following safety precautions are required for MWD training exercises.

C9.8.2.1. Store explosives in facilities that meet Q-D and other requirements of this Standard.

C9.8.2.2. Persons not essential to dog training must not be exposed to an accidental explosion during a training exercise. Evacuate nonessential personnel $D = 40\ W^{1/3}$ from the training site, if more than 15 total pounds of explosives are being used for the exercise. For 15 total pounds of explosives or less, the distance shall be a minimum of 100 feet.

C9.8.2.3. Minimize the number of samples and the quantity of explosives for each sample. The cognizant DoD Component shall determine the total quantity of explosives permitted during an exercise considering:

C9.8.2.3.1. The value and importance of the exposed facilities;

C9.8.2.3.2. The exercise operating conditions; and,

C9.8.2.3.3. The availability of evacuation space for nonessential personnel.

C9.8.2.4. Deploy samples a sufficient distance apart to prevent an explosion from propagating from one sample to another.

C9.8.2.5. Do not use blasting caps, squibs, explosive detonators, or any initiating explosive for training.

C9.8.2.6. Do not place explosives near any heat or spark producing items such as bare electrical wiring, radiators, electric heaters, heating vents, or any other source of potential initiation.

C9.8.2.7. Do not place explosives in metal containers or other confinements that would act as a source of fragments in the event of an accidental explosion.

(Approved by correspondence December 3, 1998)

C10. NEW CHAPTER 10 MILITARY OPERATIONS OTHER THAN WAR, CONTINGENCY AND COMBAT OPERATIONS

C10.1. GENERAL

C10.1.1. Full compliance with other chapters may not be possible during military operations other than war (MOOTW), contingency and combat operations . This Chapter sets the minimum levels of acceptable risk for ammunition operations supporting such operations. Services may establish implementing regulations that are more protective than this Standard. In situations involving combined or joint operations, the Commander-In-Chief of Unified or Specified Commands (CINC) or the U.S. Commander of a Joint Task Force will designate the Service explosives safety criteria to be used.

C10.1.2. This Chapter provides operational flexibility not available in other parts of this Standard. The use of asset preservation criteria contained in this Chapter is intended to maintain mission capability; however, these reduced levels of protection may impair or delay mission capability in the event of an explosives accident. This chapter's explosives safety quantity-distance (Q-D) standards include the following two levels of protection..

C10.1.2.1. Asset preservation distance. The distance that prevents propagation or reaction between potential explosion sites (PESs). (Assets at the exposed site {ES} are expected to be usable following an incident.)

C10.1.2.2. Minimum separation distance. The distance that prevents prompt propagation; however, late time propagation of reactions between PESs is possible. (Mission capability will likely be impaired.)

C10.2. SCOPE

The provisions of this Chapter apply only to:

C10.2.1. Department of Defense (DoD) ammunition and explosives (A&E) activities associated with MOOTW, contingency, and combat operations outside the continental United States (OCONUS), its territories and its possessions, when permitted by host nation laws, per Status of Forces agreements.

C10.2.2. CINC's, U.S. Commanders of Joint Task Forces or Service Component Commanders in the management of A&E during MOOTW, contingency and combat. When necessary, commanders may delegate certain explosive safety responsibilities to designated subordinate commanders to ensure appropriate controls.

C10.2.3. Contingency and combat training within the Continental United States (CONUS) and OCONUS when specifically authorized by appropriate Service headquarters or Unified Commander. Prior to approval of this training, a risk analysis that thoroughly assesses asset preservation and identifies the risk associated with the training will be conducted. Q-D distances provided for asset preservation shall be used for training, except where Chapter 9 permits lesser distances to be used.

C10.3. RISK MANAGEMENT

Consistent with operational requirements, it is DoD policy to manage risks associated with A&E. (See Chapter 1.)

C10.3.1. Equivalent protection. Exceptions to this chapter's standards are:

C10.3.1.1. Situations where an appropriate level commander determines, based on risk analysis, that an acceptable degree of safety is provided.

C10.3.1.2. Situations where the commander, based upon analysis, determines that the use of protective construction or other specialized safety features provides the required degree of safety.

C10.3.2. Risk analysis. Risk analysis is a systematic procedure consisting of the following four steps:

C10.3.2.1. An event analysis to identify and describe possible events such as the site, type of occurrence, probability and quantity of explosives;

C10.3.2.2. An effects analysis of the dangerous effects of the possible events to persons in the surroundings such as blast pressure, fragmentation, and thermal hazards;

C10.3.2.3. An exposure analysis of the places, protection and time history of possibly exposed persons in the hazardous areas; and

C10.3.2.4. A calculation of the risk.

C10.3.3. Risk control. Risk management control is the action a commander takes to minimize acceptable risk. Such actions include:

C10.3.3.1. Development, implementation, and enforcement of appropriate control measures that eliminate the hazard or reduce its risk.

C10.3.3.2. Continuous evaluation of the effectiveness of those measures implemented.

C10.4. SITE PLAN PROCESS

C10.4.1. Site approval. All explosives locations falling within the scope of this Chapter shall be approved by the DDESB or at the appropriate level of command (see paragraph C10.4.2.2.), as outlined in sub-paragraph C10.4.2. below. Site plan packages shall be submitted for the following:

C10.4.1.1. Storage locations.

C10.4.1.2. Holding areas, such as basic load ammunition holding areas (BLAHAs),flight line holding areas, port and railhead holding areas, and marshalling areas.

C10.4.1.3. Handling and operating locations, such as ports, ammunition maintenance, repair, and renovation areas and sling out areas.

C10.4.1.4. Forward rearming and refueling points (FARPs).

C10.4.1.5. Combat aircraft parking areas (CAPAs) and hot cargo parking areas.

C10.4.1.6. Static missile batteries.

C10.4.1.7. Locations used for the treatment or disposal (open burn or open detonation) of munitions. Exceptions are those locations used in an emergency response, for burning excess propellant resulting from munitions use, and those involved in direct-combat operations.

C10.4.2. Documentation requirements. The type of documentation required will be determined by the operational situation and the type and duration of explosives operations conducted at the site or facility. The following general categories of operations apply:

C10.4.2.1. Contingency and combat training

C10.4.2.1.1. Definition. Those operations at permanent or recurrent locations that simulate combat environments using live A&E to simulate real-world operations to achieve training goals.

C10.4.2.1.2. Documentation requirement. Facilities or areas for training activities must have either a DDESB approved site plan or a risk analysis approved at the appropriate level, or both.

C10.4.2.2. Permanent.

C10.4.2.2.1. Definition. Those facilities where operations are planned for more than 12 months and by virtue of operational needs fall within the scope of this Chapter.

C10.4.2.2.2. Documentation requirement. A DDESB approved

site plan for such locations must be obtained once the CINC (or Service headquarters where appropriate) determines operations will require the facilities' use to exceed 12 months.

C10.4.2.3 Recurrent.

C10.4.2.3.1. Definition. Includes facilities for periodic explosives operations such as deployments or other contingency responses. These locations may be planned using compensatory actions, such as facility evacuation or change-of-use, to minimize the risks involved by exposure to explosives operations. Use of such facilities shall be planned, coordinated, documented and approved before operations commence.

C10.4.2.3.2. Documentation requirement. These locations must have a DDESB (or appropriate level of command when applicable) approved site plan before commencing operations.

C10.4.2.4. Temporary.

C10.4.2.4.1. Definition. Those facilities for operations that are either not expected to last for protracted periods of time (12 months or less) or are of such short-notice that advanced planning and approval are impossible.

C10.4.2.4.2. Documentation requirement. In all cases, a plan for the specific scenario shall be approved by the appropriate level commander. The plan shall detail the following:

C10.4.2.4.2.1. A risk assessment for the proposed operation. This assessment will weigh the need for the facility against the potential effect of a mishap in terms of mission impact, loss of resources, turnaround times, etc.

C10.4.2.4.2.2. Milestones for transitioning the function to a "permanent" type of operation or for the cessation of explosives operations.

C10.4.3. Site plan packages. Site plan request packages shall contain the items (minimum requirements) listed below. Where operational requirements prohibit full documentation, as many of these requirements as possible will be included. (At a minimum, all documentation will include a map or drawing, the NEW, and the Q-D arc.)

C10.4.3.1. A letter of transmittal that details the proposal, along with changes, modifications, or specific precautionary measures considered necessary.

C10.4.3.2. Maps and drawings.

C10.4.3.2.1. Drawings of site plans at a scale of 1-inch equals not more than 400 feet, or metric equivalent. Drawings of a smaller scale may be necessary to properly reflect certain distances and structure relationships within the area surrounding a given site. A reduction in scale in such instances is acceptable.

C10.4.3.2.2. When standard drawings (definitive) for a building or group of buildings exist that have been reviewed by the DDESB and declared acceptable, the definitive drawings are not required. In these cases, only a site plan is required noting the definitive drawings for each building or structure to be constructed.

C10.4.3.2.3. In the absence of suitable maps or drawings, information (e.g., sketches, photographs, or other information) required to clarify the request will be provided.

C10.4.3.3. A drawing indicating the distances between the facility to be constructed, modified or used and other installation facilities, the installation boundary, public railways, and public highways, including power transmission and utility lines.

C10.4.3.4. A document that identifies all other facilities or functions including their occupancy and use within the inhabited building distance (IBD) of the facility or location to be constructed, modified or used.

C10.4.3.5. A description of hazardous materials or items to be in the PES or ES such as bombs, rockets, artillery ammunition, liquid propellants, or other items requiring protective measures of this Standard.

C10.4.3.6. The quantities, classes, and divisions of ammunition, explosives, liquid and solid propellants, or other hazardous material proposed for the subject facility or location.

C10.4.3.7. The anticipated personnel limits for the subject facility or location including a breakdown by room or bay when appropriate.

C10.4.3.8. The general details regarding construction materials, lightning protection and grounding systems, electrical power, heating systems and hazardous materials.

C10.4.3.9. A brief summary of the design procedures used if engineering protection is used to reduce the Q-D. This summary shall include a statement of the design objectives in terms of protection categories to be obtained, explosives quantities involved, design uploads applied, material properties and structural behavior assumptions, references, and sources of methods used. Detailed calculations are not required provided the protective designs used to reduce the Q-D have been approved by the DDESB. Design of explosion resistant facilities shall be accomplished by an organization or individual experienced in the field of structural dynamics using design procedures accepted by professionals in the field.

C10.4.3.10. Information on the type and arrangement of explosives operations.

C10.4.3.11. A topography map with appropriate contours when terrain features

are considered to constitute natural barricading, or topography otherwise influences layout. When such are not available, sketches, photographs, or other items that will provide information for approval will be submitted.

C10.4.3.12. An explanation of any deviations from pertinent safety standards caused by local conditions.

C10.4.3.13. A copy of the risk analysis performed by the Service Component, if one was performed, to demonstrate equivalent protection.

C10.4.4. Approval authority for waivers and exemptions. The CINC, U.S. Commander of Joint Task Forces or Service Component Commander, for strategic and other compelling reasons may authorize waivers to the explosives safety standards herein for the planning or conduct of MOOTW, contingency, and combat operations. All waivers shall be coordinated with the host nation, as appropriate, and consistent with international agreements. A necessity to deviate from minimum Q-D standards as outlined elsewhere in this Chapter should not be construed as reason to conduct explosives operations with little or no planning or controls. **All operations require adequate documentation and approval from the appropriate level of command.**

C10.4.4.1. Requests for waivers and exemptions to Q-D criteria will be per Service directives when only one Service is affected. When joint operations are being conducted from a single base or location, waivers and exemptions that affect another Service must be coordinated between the affected Service Component and approved by the designated Service Component Command.

C10.4.4.2. Requests for waivers and exemptions to Q-D criteria shall contain the following:

C10.4.4.2.1. A risk analysis for the proposed operation weighing the need to conduct the operation and violate the standards against the potential effect of a mishap in terms of mission impact, loss of resources, turnaround times, etc.

C10.4.4.2.2. A timeline listing milestones which will eliminate the need for the waiver or exemption.

C10.5. **TECHNICAL ASSESSMENT**.

The following paragraphs provide criteria for specific types of locations.

C10.5.1. General

C10.5.1.1. When applying Asset Preservation distances use public traffic route (PTR) distance $D=9.5Q^{1/3}$/$D=12Q^{1/3}$ (K24/K30) unless otherwise specified. At this distance, assets at an ES are expected to be usable following an incident at a nearby PES. For HD 1.1 apply $D=9.5Q^{1/3}$/ $D=12Q^{1/3}$ (K24/K30) and for HD 1.2, HD 1.3, and HD 1.4 apply the PTR

distance from the appropriate tables in chapter 9. Note that Q is used to represent the explosive quantity in kilograms whereas W is used to indicate weight in pounds.

C10.5.1.2. When using the Q-D criteria of this Chapter the fragmentation distance criteria contained in C2.5.2 shall be applied. Minimum fragment distance applies to facilities, locations, or supplies deemed critical to the mission. Housing (both DoD personnel and local national) and health and morale facilities (except those morale facilities that do not involve construction of buildings such as baseball diamonds, soccer fields, and running tracks or trails) are examples of such locations. For example, an above ground water supply in a desert environment should meet the fragment distance criteria in addition to the Q-D criteria contained in this Chapter. Where it is not possible to meet minimum fragment distance, engineering solutions such as sandbags and barricades may be used.

C10.5.2. Basic load ammunition holding areas (BLAHAs).

C10.5.2.1. General. To fulfill their missions, certain units must keep their basic load ammunition in readiness within the immediate vicinity of their barracks, in armored vehicles, trucks, trailers, structures, or on pads. This involves acceptance of risks to unit personnel, facilities, and equipment that are greater than permitted by other Chapter. The concept of BLAHA storage may also be used to provide Q-D separations during mobile operations.

C10.5.2.2. Mixing of basic load ammunition. Storage compatibility requirements of Chapter 3 do not apply to BLAHA facilities.

C10.5.2.3. Net explosive quantity (NEQ) NEQ net explosive weight (NEW). Net explosive quantity (NEQ) in kilograms (net explosive weight (NEW) in pounds) for use with BLAHA Q-D criteria will be determined as follows:

C10.5.2.3.1. The sum of the weights of all energetic compositions contained in munitions hazard classified as Hazard Division 1.1 or 1.5 will be used.

C10.5.2.3.2. The sum of the explosive weight of all Hazard Division 1.2 munitions will be used. The propellant weight of a Hazard Division 1.2 item (if present) may be disregarded.

C10.5.2.3.3. The weights of energetic compositions hazard classified as 1.3 may be omitted. If the site only contains Hazard Division 1.3 items the criteria contained in Chapter 9 applies.

C10.5.2.3.4. The weights of energetic compositions classified as Hazard Division 1.4 need not be considered for Q-D computations for BLAHA's.

C10.5.2.3.5. The explosive weight of Hazard Division 1.6 will be computed as follows:

C10.5.2.3.5.1. When Hazard Division 1.6 is stored alone or with Hazard Division 1.4 ammunition items, the Q-D criteria of C9 applies.

C10.5.2.3.5.2. When Hazard Division 1.6 is stored with ammunition classified as Hazard Division 1.1, 1.2 or 1.5 add the explosives weight of the 1.6 items into the NEQ calculations.

C10.5.2.3.5.3. When Hazard Division 1.6 is stored with ammunition classified as Hazard Division 1.3 add the explosives weights of Hazard Division 1.3 and Hazard Division 1.6. The Q-D criteria in C9 applies.

C10.5.2.4. Explosives limits.

C10.5.2.4.1. The maximum NEQ (NEW) at any single site in a BLAHA storing mixed compatibility must not exceed 4,000 kg (8,800 lb). A single BLAHA may have multiple 4,000 kg (8,800 lb) sites, provided the BLAHA sites are separated by the appropriate D1, D2, or D3 distances given in C10.T1.

C10.5.2.4.2. When the BLAHA or a site within a multiple bay BLAHA exceeds 4,000 kg (8,800 lb), the Q-D computations for that BLAHA site will be per Chapter 9 and explosives compatibility storage criteria of Chapter 3 applies.

C10.5.2.5. Quantity-Distance (Q-D) Computations.

C10.5.2.5.1. The total NEQ of ammunition in each site shall be used for computation of Q-D provided the required distances necessary to prevent propagation separate these sites. If the distances are not met the entire BLAHA shall be considered one site.

C10.5.2.5.2. The intermagazine separation requirements of Chapter 9 apply when using 7-Bar or 3-Bar ECM.

C10.5.2.5.3. C10.T1 contains the Q-D separation for BLAHAs as explained below:

C10.5.2.5.3.1. Column D1 is used for:

C10.5.2.5.3.1.1. Side-to-side, side-to-rear and rear-to-rear exposures between undefined earth-covered magazines (ECMs), provided the earth cover complies with paragraph C5.3.4 and the explosives are stored at least one meter (3 feet) from the end of the shelter.

C10.5.2.5.3.1.2. Non-armored sites to non-armored sites when an adequate barricade is located between the sites.

C10.5.2.5.3.1.3. Light armored vehicles to non-armored ES's when an adequate barricade is present near the non-armored ES.

C10.5.2.5.3.1.4. Light armor or non-armored PES's to light armored ES's when an adequate barricade is located between the sites.

C10.5.2.5.3.2. Column D2 is used for:

C10.5.2.5.3.2.1. Front-to-front exposures involving undefined ECMs when there is an adequate barricade at the ES.

C10.5.2.5.3.2.2. Non-armored or light armored sites to the side or rear of an undefined ECM.

C10.5.2.5.3.3. Column D3 is used for:

C10.5.2.5.3.3.1. Non-armored sites to non-armored sites without an adequate barricade.

C10.5.2.5.3.3.2. Light armored vehicles to non-armored sites without an adequate barricade at the non-armored site.

C10.5.2.5.3.3.3. Undefined ECM's to undefined ECM's when positioned front-to-front and no barricade is present.

C10.5.2.5.3.3.4. Non-armored sites, light armored sites or undefined ECM's to the front of undefined ECM's when no barricade is present at the ES.

C10.5.2.5.3.4. Column D4 is used for PTR separations from non-armored and light armored vehicles or sites.

C10.5.2.5.3.5. Column D5 is the IBD separation from non-armored and light armored vehicles or sites.

C10.5.2.5.3.6. Column D6 is used to determine the IBD and PTR separation from heavy armor vehicles. When NEQ exceeds 150 kg (330 lb) the IBD and PTR separation distances specified in chapter 9 apply.

C10.5.2.5.3.7. Heavy armored vehicles are expected to largely contain the blast and fragments from an internal explosion and are well protected from an external explosion. For this reason there is no required separation from heavy armor to light or non-armored ES's. Additionally, heavy armor requires no separation from other sites (heavy armor being the ES). The hatches of heavy armored vehicles must be kept closed to consider them as heavy armor.

C10.5.2.5.3.8. The Q-D requirements for heavy, light and non-armored vehicles or sites are contained in Table C10.T1A

C10.5.2.5.3.9. Use $D=9.5Q^{1/3}$/$D=12Q^{1/3}$ (K24/K30) instead of D1, D2 and D3 for asset preservation.

Table C10.T1. Quantity-Distance for Basic Load Ammunition Holding Areas

NEQ	NEW	D-1	D-1	D-2	D-2	D-3	D-3	D-4	D-4	D-5	D-5	D-6	D-6
KG	LB	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT
5	11	2	7	5	17	9	30	180	591	270	886	20	66
10	22	2	7	6	20	11	43	180	591	270	886	20	66
20	44	3	10	7	23	14	46	180	591	270	886	20	66
30	66	3	10	8	27	15	49	180	591	270	886	20	66
40	88	3	10	9	30	17	56	180	591	270	886	20	66
50	110	3	10	9	30	18	59	180	591	270	886	20	66
60	132	4	13	10	33	19	62	180	591	270	886	26	85
75	165	4	13	10	33	21	69	180	591	270	886	26	85
100	220	4	13	12	40	23	75	180	591	270	886	32	105
125	275	4	13	12	40	24	79	180	591	270	886	38	125
150	330	5	16	13	43	26	85	180	591	270	886	42	138
175	385	5	16	14	46	27	89	180	591	270	886		
200	440	5	16	14	46	29	95	180	591	270	886		
250	550	6	20	15	50	31	102	180	591	270	886		
300	660	6	20	16	53	33	108	180	591	270	886		
350	770	6	20	17	56	34	112	180	591	270	886		
400	880	6	20	18	60	36	118	180	591	270	886		
450	990	7	23	19	63	37	121	180	591	270	886		
500	1,100	7	23	19	63	39	128	180	591	270	886		
600	1,320	7	23	20	66	41	135	180	591	270	886		
700	1,540	8	26	22	73	43	141	180	591	270	886		
800	1,760	8	26	23	76	45	148	180	591	270	886		
900	1,980	8	26	23	76	47	154	180	591	270	886		
1,000	2,200	8	26	24	79	48	157	180	591	270	886		
1,200	2,640	9	30	26	86	52	171	180	591	270	886		
1,500	3,300	10	33	28	92	55	180	180	591	270	886		
1,750	3,850	10	33	29	96	58	190	180	591	270	886		
2,000	4,400	11	36	30	99	61	200	180	591	270	886		
2,500	5,500	11	36	33	109	66	217	180	591	270	886		
3,000	6,600	12	39	35	115	70	230	200	656	305	1,001		
3,500	7,700	13	43	36	119	73	240	215	705	330	1,083		
4,000	8,800	13	43	38	125	77	253	230	755	350	1,148		
Distance Functions		D1= 0.8 $Q^{1/3}$	K2	D2= 2.4 $Q^{1/3}$	K6	D3= 4.8 $Q^{1/3}$	K12	D4= 3.6 $Q^{1/2}$	8 $W^{1/2}$	D5= 5.5 $Q^{1/2}$	12.2 $W^{1/2}$		

Table C10.T1A. Quantity Distance for Armored Vehicles

FROM			TO		
	HEAVY	**LIGHT**	**NON-ARMORED**	**PTR**	**IBD**
HEAVY	N/R	N/R	N/R	D6	D6
LIGHT	N/R	D1	D3	D4	D5
NON-ARMORED	N/R	D1	D3	D4	D5
N/R = Not required					

C10.5.3. Ports.

C10.5.3.1. General. The following criteria shall apply to ports where A&E are off-loaded or on-loaded.

C10.5.3.2. Required separations.

C10.5.3.2.1. Explosive piers.

C10.5.3.2.1.1. Above ground intermagazine ($D= 4.4Q^{1/3}$, K11) distance shall be maintained between explosives piers.

C10.5.3.2.1.2. Intraline distance ($D=7.1Q^{1/3}$, K18) shall be maintained from an explosives pier to a non-explosives pier used for the handling of military cargo.

C10.5.3.2.1.3. Above ground intermagazine distance ($D= 4.4Q^{1/3}$, K11) shall be maintained to ammunition and explosives holding areas (A&E HA) based on the NEQ (NEW) at the pier.

C10.5.3.2.1.4. Marshalling Yards shall be located at PTR distance from explosive piers.

C10.5.3.2.1.5. Railheads used for long-term storage or as a transfer depot shall be sited at aboveground intermagazine ($D=4.4Q^{1/3}$, K11) distance from an explosives pier, based on the NEW at the pier.

C10.5.3.2.2. Explosives anchorages. The criteria of Chapter 9 applies to the use of explosives anchorages, with the following exceptions:

C10.5.3.2.2.1. Intraline distance ($D=7.1Q^{1/3}$, K18) shall be provided between the explosives loading or unloading section and the loaded ship section of an explosives anchorage.

C10.5.3.2.2.2. An explosives anchorage should be located at

$D=16Q^{1/3}$ (K40) distance from all piers. However, where necessary for security or navigational reasons, this distance may be reduced to intraline distance ($D=7.1Q^{1/3}$, K18) when the piers are utilized for only DoD operations. PTR distance shall apply for asset preservation. A separation distance of $D=16Q^{1/3}$ (K40) shall be maintained to all non-DoD related piers.

C10.5.3.2.2.3. Intraline distance ($D=7.1Q^{1/3}$, K18) is permitted between an explosives anchorage and a non-explosives DoD related anchorage. A separation distance of $D=16Q^{1/3}$ (K40) shall be maintained between an explosives anchorage and a non-explosives, non-DoD related anchorage.

C10.5.3.2.3. Explosives facilities.

C10.5.3.2.3.1. A&E Holding Areas (HAs). These holding areas are used in support of A&E on-loading and off-loading of ships. Typically, A&E being held at these locations is present for short term holding only. The NEQ (NEW) associated with the A&E HA is based on all A&E present at the site. The following apply to A&E HA:

C10.5.3.2.3.1.1. Intraline distance ($D= 7.1Q^{1/3}$, K18) shall be maintained to both explosives and non-explosives piers, based on the NEQ (NEW) present at the A&E HA..

C10.5.3.2.3.1.2 PTR distance shall be maintained to a Marshalling Yard, either explosives or non-explosives.

C10.5.3.2.3.1.3. Railheads used for A&E HA storage or as a transfer depot shall be sited at aboveground intermagazine distance ($D=4.4Q^{1/3}$, K11) from an A&E HA, based on the NEQ (NEW) at the A&E HA.

C10.5.3.2.3.2. Marshalling Yards. PTR distance shall be maintained between marshalling yards and explosive piers or A&E HAs the location of the marshalling yard will typically be governed by the NEQs (NEWs) at the other PESs. When operational necessity dictates, marshalling yards may be separated by intraline distance ($D=7.1Q^{1/3}$, K18) to nearby manned explosives operations and aboveground inter-magazine distance ($D=4.4Q^{1/3}$, K11) to nearby unmanned explosives storage operations. The criteria of paragraph E.1 of this Chapter applies.

C10.5.3.2.3.3. Railheads. Railheads shall be sited on the basis of use, e.g., classification yard, holding area or loading dock.

C10.5.3.2.3.4. Loading Docks. Loading docks shall be sited at intermagazine distance ($D=4.4Q^{1/3}$, K11) from all ESs.

C10.5.3.2.3.5. Classification Yards. Use criteria provided in Chapter 5.

C10.5.4. Field storage and handling areas.

C10.5.4.1. General. Field storage and handling areas shall be sited per C10.T2. Use separation distances from the applicable Q-D tables in Chapter 9 for the type and quanity of explosives involved with the PES

C10.5.4.2. Field storage and handling area layouts. Field storage and handling areas may consist of all or only some of the following areas:

C10.5.4.2.1. Storage sections. A location where A&E is stored. The principal objective of the field storage concept is the dispersion of ammunition to minimize loss in case of fire, accidental explosion, or enemy action. Each type of ammunition should be stored in multiple, widely separated storage sections to prevent the loss of any one section from seriously handicapping military operations. Storage section separation distances are designed to prevent simultaneous detonation from adjacent storage sections.

C10.5.4.2.2. A&E staging area. A&E staging areas are normally used as a holding area for outgoing A&E and for ready access to combat aircraft loading areas.

C10.5.4.2.3. Captured enemy ammunition area. A separate area shall be provided for the storage of captured enemy A&E. Captured enemy munitions that can not be identified shall be treated as Hazard Division 1.1.

C10.5.4.2.4. A&E operations area. An area used for operations such as minor maintenance and repair of A&E or their containers, surveillance, segregation, or weapons assembly.

C10.5.4.2.5. A&E destruction area. An area used for the destruction of A&E and may consist of a burning area or a demolition area.

C10.5.4.2.6. A&E operations area. An area used for operations such as minor maintenance and repair of A&E or their containers, surveillance, segregation, or weapons assembly.

C10.5.4.2.7. A&E destruction area. An area used for the destruction of A&E and may consist of a burning area or a demolition area.

C10.5.4.2.8. Sling out area. An area used for the movement of A&E by rotary wing aircraft.

C10.5.4.2.9. Administration and billeting areas. Inhabited locations not directly related to the daily operations of the field storage area.

C10.5.4.2.10. Boundaries. The clear zone surrounding the field storage area bound by the IBD arcs. No unrelated, occupied structures are permitted within these arcs.

C10.5.4.2.11. Manned non-explosives support facilities. Facilities that

directly support A&E operations, such as field offices and A&E support equipment maintenance facilities.

C10.5.4.2.12. Unmanned non-explosives support facilities. Unmanned locations that support A&E operations such as forklift charging stations, dunnage storage, and buildings that store inert materials. A minimum 15-meter (50-foot) separation distance shall be maintained from these locations to PESs.

C10.5.4.3. Modular storage. Modular storage refers to a barricaded area comprised of a series of connected cells separated from each other by barricades. The criteria were used in Chapter 5.

C10.5.4.4. Segregation of A&E. A&E shall be segregated by storage compatibility groups per Chapter 3.

C10.5.4.5. Storage in existing facilities. A&E may be stored in caves and tunnels as prescribed in Chapter 9.

C10.5.4.6. Barricades and revetments. The construction and use of barricades and revetments shall be per Chapter 5.

C10.5.4.7. Commercial Intermodal Containers (CIC). Containers used for transporting ammunition may be used for A&E storage and shall be sited as aboveground magazines. The containers may be sited individually or by groups
.

Table C10.T2. Quantity-Distance for Field Storage and Handling Areas

From: To:	Storage Sections	A&E Staging Area	Captured Enemy Ammunition Area	A&E Operations Area	Sling Out Area	A&E Destruction Area
Storage Sections	IM	IM	PTR	IM	IM	IN
	Note 2	Note 2	PTR	Note 2	Note 2	
A&E Staging Area	IM	IM	PTR	IM	IM	ACCORDANCE
	Note 2	Note 2	PTR	Note 2	Note 2	
Captured Enemy Ammunition Area	IM	IM	IM	IM	IM	WITH
	Note 2	Note 2	PTR	Note 2	Note 2	CHAPTER
A&E Operations Area	IM	IM	PTR	IM	IM	
	Note 2	Note 2	PTR	Note 2	Note 2	5
Sling-Out Area	NR	NR	PTR	IM	IM	
	Note 2	Note 2	PTR	Note 2	Note 2	
Administrative and Billeting Area	IBD	IBD	IBD	IBD	IBD	
	IBD	IBD	IBD	IBD	IBD	
Boundaries	IBD	IBD	IBD	IBD	IBD	
	IBD	IBD	IBD	IBD	IBD	
Manned Non-Explosive Support Facility	IL	IL	IBD	IL	IL	
	Note 2	Note 2	IBD	Note 2	Note 2	
Unmanned Non-Explosive Support Facility	NR	NR	PTR	NR	NR	
	Note 2	Note 2	PTR	Note 2	Note 2	
A&E Destruction Area - IN ACCORDANCE WITH CHAPTER 5						

Notes for Table C10.T2:

1. The distance criteria in the upper half of each row are the minimum separation distance in accordance with Chapter 9.

2. The distance criterion in the lower half of each row is the asset preservation distance. For HD 1.1 material apply $D=9.5Q^{1/3}$/$D=12Q^{1/3}$ (K24/30) separation. For HD 1.2, 1.3, or 1.4 apply PTR distances from Chapter 9 tables.

3. IM = Intermagazine Distance

4. PTR = Public Traffic Route (Includes minimum fragment distance)

5. IL = Intraline Distance

6. IBD = Inhabited Building Distance (Includes minimum fragment distance)

7. NR = Not Required

C10.5.5. Hardened Aircraft Shelters (HAS).

C10.5.5.1. As a minimum, HASs and associated storage facilities shall be separated one from another according to C10.T3. At these distances there will be a high degree of protection against propagation of explosion when HAS doors are properly secured. However, the exposed shelter may be damaged heavily and aircraft and ammunition therein may be rendered unserviceable.

C10.5.5.2. HAS and associated storage facilities spaced according to C10.T4 will provide a higher degree of asset preservation than those provided in C10.T3. An explosion in one shelter or ready storage facility may destroy it and its contents, but aircraft within adjacent shelters will be undamaged provided the doors are closed. These aircraft may not be immediately removable due to debris.

C10.5.5.3. Areas of hazard to front, side, or rear of HASs or ECMs as PESs or ESs lie in the arcs shown in C10.FA particular face of an ES is threatened by a PES face when both of these faces lie within the arc of threat or hazard of the other.

C10.5.5.4. When the PES is a third-generation HAS containing up to 5,000 kg (11,000 lb) NEQ (NEW) minimum distances from the front, sides, and rear given in C10.C4A shall be used to protect an unhardened ES against debris and blast. The quantity-distance criteria given in C10.T4A applies to all Hazard Division 1.1 ammunition and explosives regardless of any minimum fragment distance denoted by (xx)1.1.

C10.5.5.5. When operational necessity dictates, distances less than those contained in C10.T3 and C10.T4 may be approved for ESs. However it must be shown that protection equivalent to K18 is being provided
.

Table C10.T3. Minimum Quantity-Distance for Hardened Aircraft Shelters for Propagation Prevention

From: PES To: ES		1ST GENERATION HAS			2ND AND 3RD GENERATION HAS (SEE NOTE)			READY SERVICE ECM				READY SERVICE AGM	
		S	R	F	S	R	F	S	R	FB	FU	B	U
1ST GEN HAS	S	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$
	R	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$
	F	K6 $2.4Q^{1/3}$	K4.5 $1.8Q^{1/3}$	K8 $3.2Q^{1/3}$	K6 $2.4Q^{1/3}$	K4.5 $1.8Q^{1/3}$	K9 $3.6Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K6 (2) $2.4Q^{1/3}$	K9 (2) $3.6Q^{1/3}$	K6 $2.4Q^{1/3}$	K9 (2) $3.6Q^{1/3}$
2^{ND} & 3RD GEN HAS	S	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$
(SEE NOTE)	R	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$
	F	K4.5 $1.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K5 $2.0Q^{1/3}$	K4.5 $1.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K6 $2.4Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K1.25 (1) $0.5Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 (2) $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$
READY SERV ECM	S	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$						
	R	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2 $0.8Q^{1/3}$	K2 $0.8Q^{1/3}$	K2.75 $1.1Q^{1/3}$						
	FB	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K5 $2.0Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K6 $2.4Q^{1/3}$						
	FU	K6 $2.4Q^{1/3}$	K4.5 $1.8Q^{1/3}$	K8 $3.2Q^{1/3}$	K6 $2.4Q^{1/3}$	K4.5 $1.8Q^{1/3}$	K9 $3.6Q^{1/3}$						
READY SERV AGM	B	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K6 $2.4Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K6 $2.4Q^{1/3}$						
	U	K11 $4.4Q^{1/3}$	K11 $4.4Q^{1/3}$	K11 $4.4Q^{1/3}$	K11 $4.4Q^{1/3}$	K11 $4.4Q^{1/3}$	K11 $4.4Q^{1/3}$						

Legend: ECM-earth covered magazine; AGM-above ground magazine; S-side; R-rear; F-front; B-barricaded; U-unbarricaded

Notes for Table C10.T3:

1. Use $D=0.8Q^{1/3}$ (K2) if the loading density of the ECM exceeds 20 kg NEQ per cubic meter (1.25 lb NEW per cubic foot). Do not exceed the maximum NEQ (NEW) limit of 10,000 kg (22,000 lb).

2. If required, use the separation shown regardless of loading density. Do not exceed the maximum NEQ (NEW) limit of 10,000 kg (22,000 lb).

3. Second and third generation HASs are limited to a maximum of 5,000 kg (11,000 lb) per shelter.

Table C10.T4. Minimum Quantity-Distance for Hardened Aircraft Shelters for Asset Preservation

FROM: PES TO: ES		1ST GENERATION HAS			2ND AND 3RD GENERATION HAS			READY SERVICE ECM (SEE NOTE)				READY SERVICE AGM	
		S	R	F	S	R	F	S	R	FB	FU	B	U
1ST GEN HAS	S	K9 $3.6Q^{1/3}$	K6 $2.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K9 $3.6Q^{1/3}$	K6 $2.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	R	K8 $3.2Q^{1/3}$	K5 $2.0Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K5 $2.0Q^{1/3}$	K8 $3.2Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	F	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$
2ND & 3RD GEN HAS	S	K9 $3.6Q^{1/3}$	K6 $2.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K9 $3.6Q^{1/3}$	K6 $2.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	R	K8 $3.2Q^{1/3}$	K5 $2.0Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K5 $2.0Q^{1/3}$	K8 $3.2Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	F	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K2.75 $1.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
1ST GEN MAINT HAS (SEE NOTE)	S	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K9 $3.6Q^{1/3}$	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	R	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	F	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$	K18 $7.1Q^{1/3}$
2ND OR 3RD GEN MAINT HAS (SEE NOTE)	S	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K9 $3.6Q^{1/3}$	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K9 $3.6Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	R	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$
	F	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K11 $4.4Q^{1/3}$	K9 $3.6Q^{1/3}$	K18 $7.1Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$	K8 $3.2Q^{1/3}$

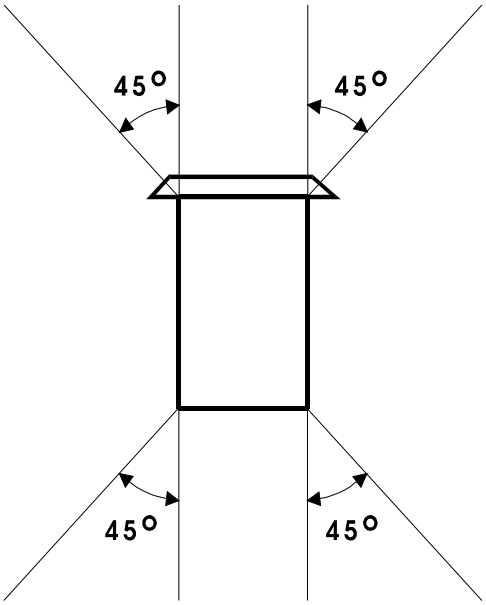
Legend: S-side; R-rear; F-front; B-barricaded; U-unbarricaded

Notes for Table C10.T4:

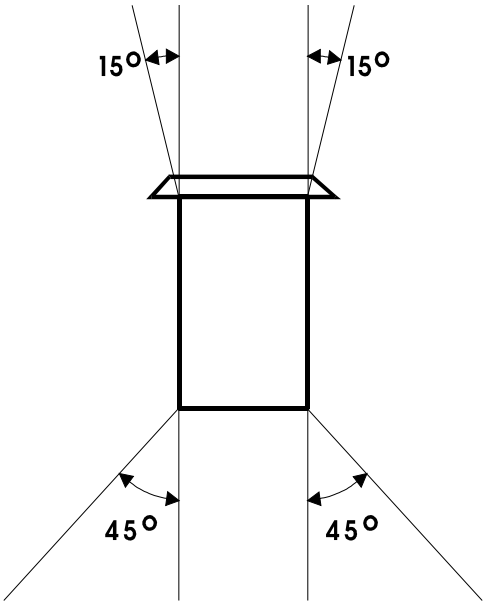
1. Maintenance HAS may not be located closer than 91M (300 feet) from any PES HAS sited for more than 225 kg NEQ (500 lb NEW).

2. Second and Third generation HAS's are limited to a maximum of 5,000 kg (11,000 lb) per shelter.

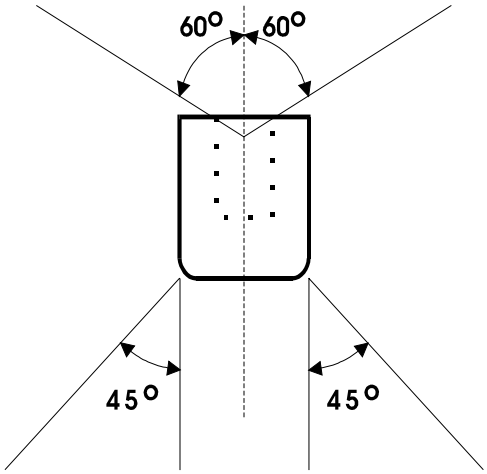
3. Ready service ECM storage is used to support daily loading and is limited to 10,000 kg (22,000 lb) per magazine and loading density not more than 20 kg NEQ per cubic meter (1.25 lb NEW per cubic foot).



HAS as Exposed Site (ES)



HAS as Potential Explosion Site (PES)



Igloo as ES or PES

Figure C10.F1. Area of Hazard

Table C10.T4A. Quantity-Distances from a U.S. Third-Generation Hardened Aircraft Shelter PES to an Unhardened Exposed Site[1,2]

NEQ (kg) [NEW (lb)]		Note	Front (meters)	Sides (meters)	Rear (meters)
from (>)	to		[feet]	[feet]	[feet]
0	2 [4.4]	3	15 [50]	15 [50]	15 [50]
2 [4.4]	50 [110]	3	70 [230]	15 [50]	15 [50]
50 [110]	225 [500]	3	70 [230]	15 [50]	15 [50]
225 [500]	500 [1100]	3	70 [230]	120 [394]	50 [164]
500 [1100]	5,000 [11,000]	4	$20Q^{1/3}$ [K50]	$25Q^{1/3}$ [K63]	$16Q^{1/3}$ [K40]

Notes for Table C10.T4A:

1. Separations are based on shelter doors remaining closed, except for aircraft towing, fueling, servicing, run-up, or taxi and during integrated combat turnarounds or short periods when maintenance equipment or munitions are being moved into or out of the shelter. Where doors are left open for extended periods, normal combat aircraft parking area criteria apply.

2. Munitions should be separated from the HAS walls at a distance sufficient to prevent breaching. For less than 500 kg, (1100 lb) a one meter (three foot) separation from the wall is sufficient.

3. The quantity-distance criteria in the table apply to inhabited building distance, public traffic route, and intraline exposures for quantities less than or equal to 500 kg (1100 lb).

4. For quantities greater than 500 to 5,000 kg (1100 to 11,000 lb), the quantity-distance criteria in the table only apply to IBD exposures. Use 50% of the IBD criteria for PTR exposures with a 91 meter (300 foot) minimum distance (out the front or rear) or a 120 meter (394 foot) minimum distance (off the sides). Use 35% of the IBD criteria for intraline exposures with a 91 meter (300 foot) minimum distance (out the front and rear) or a 120 meter (394 foot) minimum distance (off the sides).

C10.5.6. Forward Arming and Refueling Points (FARPs).

C10.5.6.1. General. The storage of ammunition and fuel at the same location is inherently hazardous and should be avoided when possible. If it is necessary to refuel and rearm aircraft at the same location, all precautions must be made to minimize the hazards involved in these operations.

C10.5.6.2. Required separations. FARPs shall be separated by IBD from all on-associated inhabited buildings. The ready ammunition storage (that ammunition staged to support the next load) shall be separated by aboveground magazine distance from the armament pads, with only armament pads considered as the PES. Ready ammunition storage structures and locations shall be separated from other ready ammunition storage structures and locations by aboveground magazine distance. Build-up locations shall be separated by aboveground intermagazine distances from all other explosives storage and operations with only the build-up locations considered as the PES. Distances prescribed by the owning service shall separate other support structures and sites. Use $D=9.5Q^{1/3}$ (K24) for asset preservation between FARPs and other ESs.

C10.5.6.3. Fuel storage. A&E shall be separated from operational fuel supplies by at least 30 meters (100 feet). Fuel supplies shall be diked or placed downhill from A&E.

C10.5.6.4. Armament pads. Armament pads shall contain the minimum amount of ammunition to conduct efficient operations. For example, where armament pads support only one aircraft, that pad will be restricted to the amount of ammunition necessary to rearm that aircraft.

C10.5.7. Airfield Operations

C10.5.7.1. General.

C10.5.7.1.1. Special consideration must be given to phased plans where the peacetime operation and positioning of aircraft transitions to contingency operations with increased quantities and use of explosives. Exposures given adequate protection under the peacetime phase may be at greater risk during the contingency phase. Commanders must consider these changes when approving these plans.

C10.5.7.1.2. The proper use of such features as barricades or earth-filled, steel-bin-type barricades (ARMCO Revetment or equivalent) (Refer to Chapter 5) can decrease the size of a potential explosive event and increase the explosives capacity of limited areas.

C10.5.7.2. Airfield Q-D criteria.

C10.5.7.2.1. Potential Explosives Site criteria. C10T5 provides criteria for airfield PESs.

C10.5.7.2.2. Exposed Site criteria.

C10.5.7.2.2.1. Runways, taxiways and combat cargo aircraft. For military use runways and taxiways use C10.T5. For joint use runways and taxiways, use criteria in C9.

C10.5.7.2.2.2 Combat aircraft support facilities. Unhardened combat aircraft support facilities shall be separated from munitions storage and operating facilities by $D=12Q^{1/3}$ (K30). For asset preservation, apply incremental $D=16Q^{1/3}$ to $20Q^{1/3}$ (K40 to K50) based on the NEQ (NEW). If these functions are located in a HAS, separation may be reduced to $D=7.1Q^{1/3}$ (K18) to the sides or rear. Site other hardened facilities as approved by the DDESB. When operational necessity dictates, distances less than K18 may be approved for Ess; however, it must be demonstrated that protection equivalent to K18 is being provided.

C10.5.8. Static missile battery separation. To ensure optimal effectiveness, offensive and defensive missile batteries must often be deployed in the proximity of other explosive operations such as field storage or flight lines in a static (non-mobile role). The following criteria apply to deployed static missile batteries (e.g., Patriots, Hawks, and Rolands) and associated support functions.

C10.5.8.1. Intermagazine separation of $D= 4.4Q^{1/3}$ (K11) shall be maintained between missile launchers, reloads and other munitions storage locations to include parked explosives loaded aircraft.

C10.5.8.2. Missile batteries deployed within the IBD clear zone of munitions storage areas may be sited at D= $7.1Q^{1/3}$ (K18) to manned functions considered related to area explosives operations. Likewise, missile batteries deployed in the clear zones of flight line operations may be sited at D= $7.1Q^{1/3}$ (K18) to manned flight line facilities.

C10.5.8.3. Those functions solely providing support to static missile units, such as motor pools, may be sited at D=$7.1Q^{1/3}$ (K18) to batteries and other explosives activities when the missile battery is located in these areas. For asset preservation, use PTR distance.

C10.5.8.4. No separation is required between missile batteries and the security force structures exclusively supporting them.

Table C10-T5. Quantity-Distance for Contingency Airfields

FROM: AIRFIELD PESs TO:	MINIMUM SEPARATION DISTANCE	ASSET PRESERVATION DISTANCE
Manned functions not related to the combat mission	IBD	IBD
Base boundaries without an easement unless manifestly unsuitable	IBD	IBD
Crew support and billeting areas	IBD	IBD
Central airfield support facilities	IL	Note 1
Functions related to the explosives mission (manned)	IL	Note 1,2
Flight line fire and rescue services	IL	Note 1
Manned munitions operating locations (assembly, maintenance, refurbishment, etc)	IL	Note 1
To any other explosives loaded aircraft or CAPA	IM	Note 1,2
Flight line Munitions Holding Area	IM	Note 1,2
Military use runways and taxiways	D=$1.8Q^{1/3}$ / K4.5	Note 1,2

Notes for C10.T5:

1. For HD 1.1 material apply D=$9.5Q^{1/3}$/$12Q^{1/3}$ (K24 / K30) separation. For HD 1.2, 1.3, or 1.4 use PTR distances from the appropriate Chapter 9 tables.

2. For aircraft, asset preservation distances may not provide protection from fragments. To protect against low-angle, high-energy fragments, aircraft should be barricaded.

C10.5.9 Emergency destruction. When it becomes necessary to destroy stores of munitions to prevent them from falling to the enemy, care must be taken to ensure that assets otherwise not in danger of falling to the enemy are not destroyed by blast or fragments. Service's shall develop specific guidance for the implementation of and training for emergency destruction of munitions. Normal disposal operations shall be conducted in accordance with Chapter 5.

C10.5.9.1. Separation from fuel.

C10.5.9.1.1. Bulk fuel storage (More than 18,900 liters (5,000 gallons)). Treat per C5.

C10.5.9.1.2. Operational storage from 1,900 to 18,900 liters (501 to 5,000 gallons). Shall be separated from each PES by at least 30 meters (100 feet). Fuel should be located downhill and diked to contain a possible fuel spill.

C10.5.9.1.3. Operational storage (1,890 liters (500 gallons) or less)). Shall be separated from each PES by at least 15 meters (50 feet). Fuel should be located downhill and diked to contain a possible fuel spill.

C11. CHAPTER 11 CHEMICAL AGENT STANDARDS

C11.1. **SCOPE AND APPLICABILITY**

C11.1.1. This Chapter sets forth standards for protecting workers and the general public from the harmful effects of chemical agents associated with research, testing, training, preservation and maintenance operations, storage, and demilitarization at laboratories, manufacturing plants and depots as well as other DOD Component agent operations, exclusive of combat training and operations. They apply to mustards: H/HD - 2,2' dich1orodiethyl sulfide, H/HT - 60% HD and 40% 2,2' dichloroethylthiodiethyl ether, L - dichloro (2-chlorovinyl) arsine; and to nerve agents: GB - isopropyl methylphosphonofluoridate, GA -dimethylaminoethoxy-cyanophosphine oxide, VX - 0-ethyl S-[2-(diisopropylamino) ethyl] methylphosphonothioate, and GD-pinacolyl methylphosphonofluoridate, as well as mixtures of these agents.

C11.1.2. Ammunition containing chemical agents may present additional hazards of blast, fragments, and thermal effects. Standards relating to explosives hazards are addressed in other Chapters and are applicable herein.

C11.1.3. Airborne Exposure Limits (AELs) established by The Army Surgeon General are maximum permissible concentrations.

C11.1.4. This Standard does not apply when the immediate disposal of chemical ammunition or decontamination of chemical agents is necessitated by an emergency and when delay clearly will cause a greater danger to human life or health.

C11.1.5. DoD Components are responsible for developing implementing instructions and safety procedures for logistical movements, training, and field operations.

C11.1.6. The requirements of DoD 5000.2-R (reference (r)) and MIL-STD-882B (reference (s)) shall be followed.

C11.2. **AIRBORNE EXPOSURE LIMITS**

C11.2.1. **Defense Installations Siting Criteria**

C11.2.1.1. **Hazard Zone Calculations.** Hazard zone calculations will conform with DDESB Technical Paper No. 10 (reference (p)). For accident/incident control, downwind hazard models (consistent with Tech Paper 10) that account for terrain effects and changing meteorological conditions may be used. For agent-filled ammunition without explosives, the maximum credible event (MCE) factors shall include the number of items likely to be involved, the quantity of agent released, and the percentage of that quantity that will be disseminated. For ammunition with explosives components, the MCE shall be based on a detonation of the explosive components that will produce the worst results regarding release of agent. The propagation characteristics of the ammunition shall be considered in developing the overall MCE. The amount of agent released and the nature of release (evaporation or aerosolization) as

a result of the MCE shall then be used to make the hazard-zone calculations for each agent as required by this Standard.

C11.2.1.2. **Installation Siting Criteria.** The hazard zone (one percent lethality distance) calculated from the MCE shall represent that arc from the agent source containing a dose of more than 10.0, 4.3, and 150.0 mg-min/m^3 of GB, VX, or mustards, respectively and 0.1 mg for inhalation-deposition of VX. Positive means shall be taken to ensure that unprotected personnel do not enter such areas as defined. Positive means shall include written procedures that must be reviewed and updated, as necessary. Positive control of an area, which can ensure that personnel can evacuate or be protected before exposure in the case of an MCE, may be developed instead of absolute exclusion. Details of such control procedures shall be included in the site and general construction plans review.

C11.2.1.3. **Controlled Agent Releases.** When by the nature of the operations a release of agent is expected (such as in the case of emergency destruction, training, or certain preventive maintenance operations), calculations shall ensure that personnel are protected within the limits established in Table C11.T1.

Table C11.T1. Airborne Exposure Limits

	Chemical Agents (mg/m^3)				
	GD	GA/GB	VX	H,HD,HT	L (Note 1)
Unmasked Agent Worker					
8-hour TWA in any work shift	3×10^{-5}	1×10^{-4}	1×10^{-5}	3×10^{-3} (Note 2)	3×10^{-3} (Note 2)
Non-agent Worker and General Population					
72-hour TWA	3×10^{-6}	3×10^{-6}	3×10^{-6}	1×10^{-4} (Note 3)	3×10^{-3} (Note 2)
Ceiling Value (maximum for time period)	3×10^{-5}	1×10^{-4}	1×10^{-5}	3×10^{-3} (Note 2)	3×10^{-3} (Note 2)
Source Emission Limit					
1-hour TWA	1×10^{-4}	3×10^{-4}	3×10^{-4}	3×10^{-2}	3×10^{-2}
Ceiling value normally refers to the maximum at any time, for any duration. Practically, it may be an average value over the minimum time to detect the specified concentration.					

Notes:

1. All concentrations measured as lewisite.

2. This value also represents the technologically feasible real time detection limit. HT is measured as HD.

3. It is recommended that this level of detection (using a 12-hour sampling time) be demonstrated and used at all sites where mustard shall be transported and destroyed.

C11.2.2. Workplace AELs

AELs are listed in Table C11.T1. AELs are time weighted average (TWAs) or ceiling values which define the permissible limits of exposure for unprotected personnel. Unmasked personnel

may not be even briefly exposed to concentrations of chemicals greater than three times the 8-hour TWA concentrations.

C11.3. AGENT EXPOSURE CONTROL AND MEASUREMENT

C11.3.1. Initial Hazard Analysis and Exposure Measurement

C11.3.1.1. A hazard analysis shall be conducted for all new operations involving chemical agents or whenever there is a change in production, process, or control measures that may result in an increase in airborne or contact concentrations of chemical agents. If the hazard analysis indicates that any operation may expose personnel to chemical agents above the AEL, control measures shall be instituted and procedures shall be established so that the actual exposure will be measured. The written record of the initial hazard analysis shall be retained as a 40-year record.

C11.3.1.2. The operation will be conducted in a manner that minimizes the public risk.

C11.3.2. Methods of Measurement

C11.3.2.1. Devices for sampling and analyzing workplace air shall measure and alarm within 10 minutes when chemical agents are present in excess of the 8-hour TWA concentrations.

C11.3.2.2. When the interior of reservoirs, pipes and such systems are sampled, the volume of the area being sampled as well as the volume of the sample must be recorded and associated with the results.

C11.3.2.3. Decontaminating solutions will not be analyzed for residual agent for the purpose of certifying a level of decontamination. Suspected agents will be extracted from samples with suitable solvents where analyses are required. Air may be an appropriate solvent for volatile agents.

C11.3.3. Exposure Control

C11.3.3.1. When exhaust systems are used to control exposure, measurements of system effectiveness such as static pressure shall be made at the start of each operation and at least every 3 months.

C11.3.3.2. Before beginning chemical operations, a determination shall be made that the hazard zone associated with those operations is under positive control in accordance with subsection C11.2.1., above.

C11.3.3.3. If personnel exposures will equal or exceed the applicable AEL, personnel shall be protected by the use of personnel protective equipment (PPE) specifically approved by the DoD Component medical authority concerned or as indicated in Table C11.T2.

C11.3.3.4. Procedures will be developed to address hazards involved in maintenance and repair operations.

Table C11.T2. Protective Equipment for Regulated Areas (Note 1)Employee Exposure Potential. (Note 2)

Occupational Scenario	Chemical Agents (mg/m^3)				
	GD	GA/GB	VX	H,HD, & HT	L
1. Unmasked Agent Worker					
A full facepiece, chemical canister, air purifying protective mask shall be on hand for escape. (The M9, M17 or M40 series masks are acceptable for that purpose. Other masks certified as equivalent may be used.) (Note 5)	3×10^{-5} (Note 3)	1×10^{-4} (Note 3)	1×10^{-5} (Note 3)	3×10^{-3} (Note 4)	3×10^{-3} (Note 4)
2. Masked Personnel in Routine Operations					
a. A NIOSH and/or MSHA approved pressure demand full facepiece SCBA or supplied air respirator with escape air cylinder may be used. b. Alternatively, a full facepiece, chemical canister air purifying protective mask is acceptable for that purpose (i.e., M9, M17, or M40 series or other certified equavalent.) (Note 5)	$>3 \times 10^{-5}$ to 6×10^{-2}	$>1 \times 10^{-4}$ to 2×10^{-1}	$>1 \times 10^{-5}$ to 2×10^{-2}	3×10^{-3}	3×10^{-3}
3. Operations Personnel Conducting Emergency Operations or Operations in Unknown but Potentially High Agent Concentrations					
a. NIOSH and/or MSHA approved pressure demand full facepiece SCBA suitable for use in high concentrations agent with protective ensemble. (Notes 7 & 8) b. During emergencies, the best available respiratory protection and personnel ensemble must be used. If protection in 3a above is not available, use of a full facepiece, chemical canister, air purifying protective mask with hood is acceptable. Only the M9 series mask with Mil canister is acceptable. (Notes 7 & 8)	$>6 \times 10^{-2}$	$>2 \times 10^{-1}$	$>2 \times 10^{-2}$	$>3 \times 10^{-3}$ (Note 6)	$>3 \times 10^{-3}$ (Note 6)

Notes for Table C11.T2.:

1. Qualitatively fit all workers required to use respiratory protective devices. Quantitative fit testing may be performed using surrogate masks.

2. Based on an 8-hour TWA measurement. All values on this table are 8 hour TWA unless otherwise noted. The TWA is the concentration to which nearly all workers may be repeatedly exposed, for a normal 8-hour workday and 40-hour

workweek, day after day, without adverse effects. TWAs permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. Excursions above the TWA should be controlled even where the 8-hour TWA is within recommended limits.

3. Determined by required continuous air monitoring.

4. This represents ceiling value determined by continuous real time monitoring (with alarm) at the 0.003 mg/m^3 level of detection; immediate respiratory protection available in case concentration rises above 0.003 mg/m^3; potential exposure by any route limited by engineering and work practice controls to the extent practicable.

5. Air-purifying masks may NOT be used in oxygen deficient atmospheres.

6. Due to the potential carcinogenicity of agents H and L, the highest level of respiratory and dermal protection should be provided to all workers exposed; i.e., a NIOSH and/or MSHA approved, pressure demand, full facepiece SCBA or supplied air respirator suitable for use in high concentration atmospheres. An air-purifying protective mask is not suitable for this purpose.

7. Examples of such protective ensembles include toxicologic agent protective ensemble, self-contained (TAPES) and the demilitarization protective ensemble (DPE).

8. For emergency masked escape, a full facepiece, chemical canister, air-purifying protective mask (M9, M17, or other certified equivalent) is acceptable.

C11.4. MEDICAL SURVEILLANCE

Preassignment and annual health assessments shall be provided for each employee to establish a baseline health record and to provide counseling on health matters as related to the chemical agent operations. Annual assessments will be used to determine deviations from the baseline.

C11.5. WORKER PROTECTIVE CLOTHING AND EQUIPMENT

C11.5.1. Positive engineering and administrative controls shall be incorporated in all operations involving chemical agents to preclude or minimize the need for personal protective equipment.

C11.5.2. A respiratory protection program shall be established in conformance with DoD Instruction 6055.1 (reference (t)) for approved respiratory requirements. The wearer's face shall be clean-shaven to the extent that there is no interference of any facial hair growth with the sealing surfaces of the protective mask. Personnel with beards shall be denied access to agent storage and operating areas, unless suitable emergency egress respirator(s) can be provided.

C11.5.3. Personnel shall use approved protective clothing as determined by the hazard analysis.

C11.6. ADMINISTRATIVE AND WORK PRACTICE CONTROLS

C11.6.1. Containment

C11.6.1.1. Containment is the principal control measure for prevention of exposure of personnel to agents from inherently hazardous operations.

C11.6.1.1.1. Total containment requires the equipment or facility to be of a tested design capable of containing all the reaction gases, detectable agent, and fragments from the largest explosion or detonation that could occur without causing equipment or facility rupture or leakage. Total containment is required for those operations involving ammunition that contain explosive components as well as agents, whenever the operation may subject the explosive components to a potential initiating stimulus. Operations requiring total containment include:

C11.6.1.1.1.1. Chemical ammunition cutting, sawing, milling, drilling, punching, or shearing operations that require the machine tool to remove or displace metal before or after contact with the explosives.

C11.6.1.1.1.2. Operations in which the ammunition arming and functioning environments can be duplicated by the equipment or process.

C11.6.1.1.1.3. Disassembly of armed or possibly armed ammunition.

C11.6.1.1.1.4. Disassembly of explosive components from ammunition that requires application of significantly greater leverage or torque than that required for assembly.

C11.6.1.1.2. Vapor containment requires the equipment or facility to be of a tested design capable of containing nonexplosion releases of agent. Vapor containment is required for those operations involving agents without explosives components and for those operations involving ammunition containing both agent and explosive components that do not subject the explosive components to a potential initiating stimulus. Operations requiring vapor containment include:

C11.6.1.1.2.1. Chemical ammunition punching, drilling, or sawing operations for removal of agents.

C11.6.1.1.2.2. Burster-well removal.

C11.6.1.1.2.3. Transfer of agent from bulk storage tanks, containers, or ammunition into holding tanks, chemical detoxification reactors, incinerators, or similar processing equipment, such as may be found in a production, demilitarization, or disposal line. This is not to be construed as requiring vapor containment for agent transfer during field operations involving leaker repair activities.

C11.6.1.1.2.4. RDT&E Test Chamber operations.

C11.6.1.2. Containment is not required for operations associated with field storage and maintenance activities (such as shipping, storage, receiving, rewarehousing, minor maintenance, surveillance inspection, repair, encapsulation and emergency agent transfer in the event of leakage).

C11.6.2. **Training and Information.** All who work directly with chemical agents and ammunition (agent workers, firefighters, medical, and security personnel) shall receive enough training to enable them to work safely and to understand the relative significance of agent exposures. This training shall include information on sources of exposure, possible adverse health effects, practices and controls being used to limit exposures, environmental issues, medical monitoring procedures in use and their purposes, and employee responsibilities in health protection programs. In addition to this training, fire protection workers shall be familiar with the contents of the following references:

C11.6.2.1. Chemical Agent Data Sheets (reference (u)).

C11.6.2.2. Joint Chemical Biological (CB) Technical Data Source Book (reference (v)).

C11.6.2.3. Special Occupational Safety and Health Standard for the Evaluation and Control of Occupational Exposure to Agent GB (reference (w)).

C11.6.3. **Recordkeeping.** Recordkeeping pertaining to exposure determination and measurement, mechanical ventilation, employee training, medical surveillance, and access to records shall be consistent with DoD Instruction 6055.5 (reference (x)).

C11.6.4. **Labeling and Posting of Hazards**

C11.6.4.1. Signs and labels to warn personnel of hazards of chemical agents are required for work areas, for containers of chemical agents, for contaminated clothing and equipment, and for identification of restricted-use areas.

C11.6.4.2. When opportunity for agent contamination exists, equipment, tools, or other items shall be marked, tagged or segregated to indicate degree of decontamination undergone or that the facility or item never has been exposed to chemical agents, whichever is appropriate.

C11.6.4.2.1. An agent symbol with a single "X" indicates the item has been partially decontaminated of the indicated agent. Further decontamination processes are required before the item is moved or any maintenance or repair is performed without the use of chemical protective clothing and equipment. This degree generally shall be applied to the item as it stands in place after being used and subjected only to routine cleaning after use.

C11.6.4.2.2. An agent symbol with three "Xs" indicates that the item has been surface decontaminated by locally approved procedures, bagged or contained in an agent-tight barrier, of sufficient volume to permit sample air to be withdrawn without being diluted with incoming air, and that appropriate tests or monitoring have verified that concentrations of 0.0001 mg/m^3 for agent GB, 0.00001 mg/m^3 for agent VX, 0.003 mg/m^3 for H or L, or (Unmasked worker AEL values for other covered chemicals) do not exist. Monitoring is not required for completely decontaminated and disassembled parts that are shaped simply (no

crevices, threads, or the like) and are made of essentially impervious materials (such as simple lab glassware, and steel gears).

C11.6.4.2.3. An agent symbol with five "Xs" indicates an item has been decontaminated completely of the indicated agent and may be released for general use or sold to the general public. An item is decontaminated completely when the item has been subjected to procedures that are known to completely degrade the agent molecule, or when analyses, approved by the DDESB, have shown that the total quantity of agent is less than the minimal health effects dosage as determined by the Office of the Surgeon General of the Army.

C11.6.4.3. Rooms containing or suspected of having been contaminated with agents shall be marked (near each entrance) at all times to indicate the level of contamination to be expected by entering personnel. This requirement does not apply to magazines.

C11.6.4.3.1. **5R - No Agent Hazard.** An agent symbol with five "Rs" means that all previously contaminated surfaces are decontaminated and analyzed to demonstrate the absence of residual agents. A room sealed (ventilation turned off) for at least 4 hours at a temperature of at least 70 degrees Fahrenheit prior to sampling which shows an agent vapor concentration less than the 8 hour TWA concentration for unmasked workers is considered "5R".

C11.6.4.3.2. **4R - Controlled Agent Vapor Hazard.** An agent symbol with four "Rs" means that all previously contaminated surfaces are decontaminated by locally approved procedures, and air sampling indicates agent concentrations less than the 8-hour TWA(s) for unmasked workers. The air is sampled (at a temperature of 70 degrees Fahrenheit or greater) with the normal ventilation system operating.

C11.6.4.3.3. **3R - Contained Agent Hazard.** An agent symbol with three "Rs" indicates that any agents are in configurations which, if left undisturbed, should prevent agent vapor or contact hazards.

C11.6.4.3.4. **2R - Agent Vapor Hazard.** An agent symbol with two "Rs" indicates that any agents are in configurations which, if left undisturbed, prevent contact hazards.

C11.6.4.3.5. **lR - Agent Hazard.** An agent symbol with one "R" indicates the possibility of agent contact or vapor hazards, or agents in singly contained configurations which may leak. This includes rooms being used for operations which may cause agents to be released from engineering controls due to unforseen accidental causes such as in routine laboratory operations in fume hoods.

C11.6.5. **Emergencies**

C11.6.5.1. In case of accidental release of an agent that may result in personnel exposure, all nonessential and unprotected personnel shall evacuate immediately. Contaminated areas must be decontaminated, as appropriate, to applicable Table C11.T1. AELs before normal operations are resumed.

C11.6.5.2. Special medical surveillance shall be started within 24 hours for all personnel present in the potentially affected area at the time of the emergency.

C11.6.5.3. The DoD Component shall maintain up-to-date Chemical Accident and Incident Control plans and conduct practice exercises of these plans at least annually.

C11.6.6. **Chemical Agent Decontamination**

C11.6.6.1. When chemical agents are spilled, or released, immediate action will be taken to contain the spill and clean up the agent in the immediate area of the spill.

C11.6.6.2. Before leaving contaminated work areas, the external surfaces of the outer garments, and the protective boots and gloves shall be decontaminated.

C11.6.6.3. When protective clothing becomes contaminated with chemical agents, the outside layer of clothing shall be removed and decontaminated as soon as possible.

C11.6.6.4. Protective clothing and equipment that has been worn in known contaminated areas (agent detected) shall be decontaminated and monitored before reuse. Protective clothing and equipment contaminated with liquid mustard will not be reused. Protective clothing and equipment that has been worn in potentially contaminated areas (when no agent leakage has been visually observed or detected by use of field detection equipment) will be monitored before being moved to areas accessible to nonagent personnel.

C11.6.6.5. Monitoring of protective clothing and equipment shall include containerization at 70 degrees Fahrenheit or higher for at least 4 hours, with subsequent analysis of a portion of the interior atmosphere of the container for the agent. The volume of the container, as well as the sample volume must be noted. See paragraph C11.6.4.2., above. Plastic bags may be used as the container, if they have been tested and found to be effective for the purpose.

C11.6.6.6. Since mustard penetrates into many protective materials with time, reuse of any protective clothing that has been contaminated with liquid mustard is not permitted.

C11.6.6.7. Protective clothing that, after routine decontamination, is found to emit agent concentrations above the 3X level shall be destroyed.

C11.6.6.8. Before chemical disposal systems are converted to different agents, piping, tanks, and so forth, of chemical disposal systems will be filled with decontaminating solution and a contact time of 10 half lives or greater will be provided. Walls and floors of process areas will be decontaminated to ensure the absence of contact hazards.

C11.6.7. **Recertification of Protective Clothing.** After decontamination, clothing that has been determined to be 3X may be laundered, visually examined, and recertified by the DoD Component for use. Other items of toxicological agent protective clothing, such as boots and gloves, shall be tested, laundered, and recertified for use in the same manner.

C11.6.8. **Transportation of Materials Contaminated with Chemical Agents**. Materials contaminated with chemical agents may be transported from one location to another. The material shall be encapsulated within an agent tight barrier. The following must be placed in compatibly lined drums or provided with other suitably tested containment before being transported: items potentially contaminated with liquid toxic chemical agent, items failing a XXX determination, or items suspected of offering hazards of percutaneous exposure to a chemical agent.

C11.6.9. **Transportation of Bulk Agents and Chemical Ammunition**. The requirements established by AR 740-32, OPNAVINST 8070.1B, AFR 136-4 and MCO 4030.25B (reference (y)) shall be satisfied.

C11.7. ENGINEERING DESIGN GUIDANCE FOR FACILITIES

C11.7.1. **Air Ventilation Systems.** Air ventilation systems shall be designed and periodically tested to ensure that control of agent-contaminated exhaust will not exceed source emission limit of Table C11.T1. Other design features that afford the same degree of safety may be used.

C11.7.1.1. Filters or scrubbers for exhausted air shall be designed and approved for the MCE of the operations involved.

C11.7.1.2. When high concentrations of agent are involved and breakthrough of agent can be expected, use of redundant filters shall be employed. Filters will be changed when agent breaks through the filter which is just upstream of the last filter as indicated by a gas life indicator, or calculations show that the first filter has absorbed one half of its design capacity.

C11.7.1.3. All exhaust equipment will have backup blowers that engage automatically if the main blower fails.

C11.7.1.4. Filter systems will be fitted with the means to measure the pressure drop across the filters.

C11.7.1.5. Exhaust hoods and glove boxes will be designed to contain agents so that concentrations specified in Table C11.T1. for unprotected personnel are not exceeded outside engineering controls. The design of these items will permit airflow adjustments sufficient to maintain the required protection level when laboratory equipment is in place.

C11.7.1.5.1. Catch basins and traps or spill trays of suitable size shall be provided within hoods and glove boxes.

C11.7.1.5.2. Glove boxes shall be used when the hazards analysis indicates that agent aerosols or dusts may be present during an operation.

C11.7.1.6. Special design features shall be used when exposed explosives are

involved to segregate explosives from air ventilation systems.

C11.7.2. **Mechanical and Utilities Design for Facilities**

C11.7.2.1. The design parameters shall consider equipment and process layout, makeup airflow, and operational positions with regard to maintaining flow balance and cross currents. The system shall maintain negative pressure in operating areas in relation to hallways, offices, and other nonagent areas.

C11.7.2.2. Working surfaces, such as walls, floors, and ceilings within a facility likely to be agent-contaminated during regular or accidental situations shall be constructed of agent resistant materials. Flooring shall cover wall surfaces to a height of 6 inches.

C11.7.2.3. Utilities, mechanical rooms, and other nonagent areas shall be located so that air flows toward agent operating areas. Access to these non-agent areas shall be accomplished without entry into agent areas.

C11.7.2.4. The electrical system shall be equipped with a backup power source designed to start automatically and supply enough power to support critical functions in the event of power outage. Wiring, controls, lightning protection, and other electrical devices shall meet the same requirements as defined in Chapter 6 and Chapter 7.

C11.7.2.5. Safety showers and eyewash fountains shall be readily accessible to all personnel working with hazardous materials and shall be tested periodically.

C11.7.2.6. All water outlets in the agent operational facility shall be fitted with effective devices to prevent backflow of water into the service lines.

C11.7.2.7. Dedicated liquid waste systems shall be designed to collect and maintain any potentially agent-contaminated effluent produced by the activity until disposal in accordance with applicable laws. Vents or other openings in the waste system shall be fitted with approved agent filters.

C11.7.2.8. Decontamination facilities of sufficient capacity to catch and contain liquid effluents shall be provided for agent operations. Adequate decontamination solution shall be available for immediate use on personnel or on facilities.

C11.7.2.9. When operations require work assignments to be conducted at exposure levels above or potentially above the AEL for unprotected workers, change facilities with showers shall be provided.

C11.7.3. **General Design Considerations**

C11.7.3.1. **Facility Alarms and Monitors for Engineering Systems.** Each

chemical facility shall have a master alarm and control panel that will permit functional verification of the exhaust blowers and airhandlers. Visual and audible alert alarms will be keyed to this master alarm panel to indicate failures.

C11.7.3.2. **Fire Detection and Protection.** Fire detection and protection systems for production and maintenance facilities shall comply with the requirements and guidelines published in ARLCD-CR-80049 (reference (z)).

C11.7.3.3. **Bulk Storage Tanks.** Impermeable dikes of enough capacity to hold at least 110 percent of the tank capacity plus the required volume of decontaminant solution shall be placed around all bulk agent tanks, reactors, and mixers. A system designed to pump the agent from the dikes to a vessel designed to accommodate the decontamination will satisfy the requirement that the dike contain sufficient volume for the decontaminating solutions.

C11.7.3.4. **Isolation of Facility Functions**. The agent facilities will be designed to isolate unrelated activities by physical barriers or approved engineering controls. Design criteria shall prevent explosives from entering drain lines and sumps containing agents.

C11.7.3.5. **Monitoring**. Air monitoring stations shall be established around chemical operational areas and storage areas to determine if Table C11.T1. AELs are exceeded. In laboratory environments this requirement is met by routine area monitors and stack sampling.

C11.7.3.5.1. Monitoring analyses conducted for the purpose of demonstrating compliance with AELs will be based on certified reference materials.

C11.7.3.5.2. Monitoring analyses conducted for the purpose demonstrating compliance with AELs will be conducted under quality assurance plans that address the following issues:

C11.7.3.5.2.1. Production, characterization, and storage of certified reference materials.

C11.7.3.5.2.2. Documentation of precision, accuracy and quantification limits of analytical methodology.

C11.7.3.5.2.3. External oversight of laboratory results.

C11.7.3.6. **Agent Operational Areas.** The chemical handling and maintenance areas associated with industrial operations shall be isolated from the main facility and shall be operated at a negative pressure with respect to the main facility area. The agent handling rooms shall be equipped with local exhaust ventilation which may be cascaded to more contaminated areas and exhausted out of a common exhaust stack. All air leaving the facility shall be filtered through redundant filter banks or other DDESB approved methods of decontaminating contaminated exhaust. The flow of air (negative pressures) shall go from less hazardous to more hazardous as based upon agent concentrations.

C11.8. CLASSIFICATION OF MILITARY-PECULIAR CHEMICAL MATERIALS AND AMMUNITION

C11.8.1. **Chemical Materials.** For purposes of storing and handling, chemical materials have been divided into groups as listed in Chapter 3, section C3.4., as subdivided below, based on the action of the agent, the degree and type of hazard and the type of protection required.

C11.8.1.1. **Chemical Group A.** Group A shall include highly toxic liquid agents, which in either liquid or vapor form, may be absorbed through the respiratory tract, the skin, or the eyes (for example, nerve agent, mustard). Exposure to Chemical Group A agents may cause serious damage to body functions or death, depending on the degree of exposure involved. Protection from these agents requires that full coverage, protective clothing and protective mask be worn.

C11.8.1.2. **Chemical Group B.** Group B (for example, Phosgene, CN, CN-DM, BZ, CS, NC, etc.) shall include chemical materials (gaseous, liquids or solids) which are toxic or incapacitating by inhalation, ingestion or percutaneous absorption. Wearing of suitable respiratory protection is required for the protection of personnel against inhalation of vapors, particles or smoke from burning agents. Exposure to these materials may be fatal. Since these agents will cause varying degrees of skin irritation, approved types of protective clothing (such as coveralls, respiratory protection, gloves, and so forth) shall be provided and worn. This group consists of choking agents, blood agents, riot control agents, and screening smokes.

C11.8.1.3. **Chemical Group C.** This group shall include materials which are spontaneously combustible (WP and PWP) and for which special fire fighting techniques and materials are required. Personnel protection will be of the type that will provide protection against fire and heat. Protection from inhalation of smoke from burning materials is required.

C11.8.1.4. **Chemical Group D.** This group consists of signaling smokes and incendiary (for example, TH, IM, NP, PTI) material for which conventional fire fighting methods except use of water may be used. Protection from inhalation of smoke from burning incendiary mixtures is required.

C11.8.2. **Chemical Ammunition.** The same group designations used for chemical materials shall be used for chemical ammunition. The chemical and storage compatibility groups are the same for the chemical material and the ammunition item containing the material.

C12. CHAPTER 12 REAL PROPERTY CONTAMINATED WITH AMMUNITION, EXPLOSIVES OR CHEMICAL AGENTS

C12.1. SCOPE

This Chapter contains particular policies and procedures necessary to provide protection to personnel as a result of DoD ammunition, explosives or chemical agent contamination of real property currently and formerly owned, leased or used by the Department of Defense. This includes manufacturing areas including pads, pits, basins, ponds, streams, burial sites and other locations incident to such operations. This requires identification and control measures that are in addition to, not substitutes for, those generally applicable to DoD real-property management. Contamination as used in this Chapter refers in all cases to contamination with ammunition, explosives or chemical agents.

C12.2. POLICY

C12.2.1. Every means possible shall be used to protect members of the general public from exposure to hazards from contaminated real property currently or formerly under DoD ownership or control.

C12.2.2. Permanent contamination of real property by final disposal of ammunition and explosives or chemical agents is prohibited. This prohibition extends to disposal by land burial; by discharge onto watersheds or into sewers, streams, lakes or waterways. This policy does not preclude burial to control fragments during authorized destruction by detonation when these procedures are authorized by the DoD Component concerned, and compliance with applicable statutes and regulations relative to environmental safeguards is ensured.

C12.2.3. Real property that is known to be contaminated with ammunition, explosives or chemical agents must be *remediated* with the most appropriate technology to ensure protection of the public consistent with the proposed end use of the property.

C12.3. PROCEDURES

C12.3.1. Identification and Control (Active Installations)

C12.3.3.1. Permanent records shall be created and maintained for each installation, ammunition plant, depot, laboratory, range, and ammunition holding areas to identify clearly all contaminated areas. These records shall indicate known and suspect areas, positively identify contamination by nomenclature, hazard, quantity, exact locations, and dud rates. All decontamination efforts shall be similarly detailed. If the installation is deactivated, the decontamination records shall be transferred to the office designated by the DoD Component concerned to ensure permanent retention.

C12.3.3.2. All contaminated locations shall be placarded appropriately with

permanent signs that prohibit entrance of unauthorized personnel. The DoD Component concerned shall ensure periodically that such signs are restored and maintained in a legible condition.

C12.3.3.3. Active firing ranges, demolition grounds, and explosives test areas shall be assumed to be contaminated with unexploded ordnance (UXO) explosive material and shall be controlled accordingly. Access to these areas shall be controlled by the DoD Component.

C12.3.2. **Land Disposal (Active Installations)**

C12.3.2.1. The plans for leasing, transferring, excessing, disposing and/or remediating DoD real property when ammunition, explosives or chemical agents contamination exists or is suspected to exist, shall be submitted to DDESB for review and approval of explosives safety aspects.

C12.3.2.2. DoD Component land disposal submissions shall state the intended end use of the property, the nature and extent of on and off post contamination, location of the contaminated land, any improvements that may have been made, proposed detection and degree of decontamination and the extent to which the property may be used safely without further decontamination.

C12.3.2.3. When accountability and control of real property contaminated with ammunition and explosives are transferred among DoD Components, the action shall be accompanied by the permanent record of contamination.

C12.3.2.4. Ammunition, explosives or chemical agents shall be removed until an acceptable level of protection is reached. Identification of degree and extent of contamination, assessment of potential for migration of contamination, and implementation of steps to halt such migration are necessary to accomplish proper cleanup. In addition, ammunition and explosive contamination shall be removed to appropriate depths in limited areas where the user activity warrants it. Transfer records shall detail past ammunition and explosive contamination and decontamination efforts; provide requisite residual contamination information; and advise the user not to excavate or drill in residual contamination area without a metal detection survey. This information shall be enclosed along with the report of excess. This information will also be entered in the permanent land records of the civil jurisdiction in which the property is located.

C12.3.2.5. Limited use land transfers may be arranged with other federal agencies for compatible use of contaminated real property such as wildlife refuges, safety zones for federal power facilities, or other purposes not requiring entry except for personnel authorized by the DoD Component concerned. These land transfers shall include all restrictions and prohibitions concerning use of the real property to ensure appropriate protection of both operating personnel and the general public.

C12.3.3. **Remediation of Formerly Used Defense Sites (FUDS)**

C12.3.3.1. The DoD Component responsible for the remediation of the FUDS shall develop procedures to safely remediate those sites contaminated with ammunition, explosives or chemical agents. These procedures will be provided DDESB for review and approval. Priority will be given to the remediation of sites with contamination that poses an immediate public risk. Identification of the degree and extent of contamination, assessment of potential for migration of contamination, and implementation of steps to halt such migration will complement efforts to clean up FUDS.

C12.3.3.2. Plans for the remediation of FUDS must be submitted to the DDESB for coordination (with regard to explosives and chemical agent safety). These plans should present the type of contaminations that are suspected to exist at the site, the techniques that will be used for the identification of the contamination, a risk assessment, and the measures that will be taken to minimize the risk to workers and the public during the contamination assessment, cleanup and disposal phases. The DDESB will be notified if significant hazards arise during any of the above phases and require actions beyond the DDESB-approved FUDS procedures or actions beyond the specific FUDS remediation plan initially submitted for coordination by the DDESB.

C12.3.4. **Remediation Methods and Use Restrictions**

C12.3.4.1. **Remediation Planning.** The depth to which UXO remediation is necessary depends on the projected end use of the land and the extent of human exposure.

C12.3.4.1.1. Information concerning the remediation and notification that additional cleanup is necessary before further and/or different use will be included in applicable land disposal documents.

C12.3.4.1.2. The intended end use may be defined in congressional legislation or the end user which can be any combination of federal, state, local and private entities.

C12.3.4.1.3. The land's projected end use must be changed in those cases where UXO detection systems are not sensitive enough or funds are not available to remove UXO to the remediation depth.

C12.3.4.1.4. Documents about the remediation depth to which UXO was removed and the process by which that depth was determined must be included in the land disposal documents.

C12.3.4.2. **Remediation Process.** Remediation involves removing UXO from the specific parcel of land being transferred. This process includes several steps:

C12.3.4.2.1. Determine the land end use. The end use may be provided externally or may be DoD-recommended. Within a parcel of land, there may be multiple uses, such as wildlife refuge, livestock grazing, public highway and picnic area.

C12.3.4.2.2. Determine the boundaries of the area(s) to be researched and remediated.

C12.3.4.2.3. Determine known or suspected UXO by type.

C12.3.4.2.4. Define the locations of UXO and the remediation depth(s).

C12.3.4.2.5. Remove or neutralize UXO.

C12.3.4.2.6. Document the process.

C12.3.4.2.7. Make provisions for continued DoD surveillance of areas where UXO is above the frost line yet located below the remediation depth. (The Corps of Engineers is responsible for actions involving land returned to the public domain.) Such UXO will eventually migrate to the surface and additional remediation will be required.

C12.3.4.3. **Site-specific Remediation Depth Determination.** The preferred method to determine the remediation depths is to use site-specific information. The following information is needed for site specific determination:

C12.3.4.3.1. Characterize the site including the boundaries, types of ordnance, and soil characteristics. This is done through searching historical documents, interviews and on-site investigation, as appropriate.

C12.3.4.3.2. Provide the estimated depth at which UXO may be present based on available records, technical data, and/or on-site investigation, as appropriate. This may be accomplished using a MAXIMUM ORDNANCE PENETRATION source document, such as the NOMOGRAPH found in figure 4-8, TM 5-855-l (reference (aa)).

C12.3.4.3.3. Using UXO depth estimate(s), establish remediation depths for the site-specific conditions.

C12.3.4.4. The approved remediation plan may be modified based on actual conditions encountered during the remediation. For example, should UXO be consistently found at less than the predicted depths, the remediation depth may be reduced. The modification(s) will be documented, forwarded to DDESB for approval, and included in the land disposal agreements.

C12.3.4.5. **Assessment Depth.** When site specific planning described in paragraph C12.3.4.3., above, is not possible, the assessment depths provided below are used for interim planning.

Planned End Use	Depth
Unrestricted Commercial/Residential/ Utility/Subsurface Recreational Construction Activity	10 Ft *
Public Access Farming/Agriculture/Surface Recreation/Vehicle Parking/Surface Supply Storage	4 Ft
Limited Public Access Livestock Grazing/Wildlife Preserve	1 Ft
Not Yet Determined	Surface
Like Use (Remediation will be consistent with Service regulations concerning routine maintenance of impact areas).	

(Assessment planning at construction sites for any projected end use requires looking at the possibility of UXO presence 4 ft below planned excavation depths).

C12.3.4.6. Land disposal agreements must include notice that there could be increased risks to operations and public safety if violations of the end use were to occur.

C12.3.5. ***Termination of Use of Facilities Storing Ammunition and Explosives.*** *Each storage facility no longer used to store ammunition and explosives must undergo a process to ensure that ammunition, explosives, and any visible explosives residues are removed within 180 days from the last use of the storage facility. Those procedures help ensure that no threats to human health or the environment remain when the unit is no longer to be used to store ammunition and explosives. (Ammunition storage units (ASUs) that have been used to store waste military munitions must also comply with the closure procedures in Chapter 14, section C14.6.) Those procedures shall include the following:*

C12.3.5.1. Emptying the storage facility of all ammunition and explosives and related materials.

C12.3.5.2. Cleaning the storage facility, as required, to remove any visible explosives residue.

C12.3.5.3. Visually inspecting the storage facility for the presence of remaining ammunition or explosives or visible explosives residue by a knowledgeable individual that the installation or responsible activity commander appoints.

C12.3.5.4. Removing from the storage facility all fire and chemical hazard symbols and marking the storage facility as empty.

C12.3.5.5. Securing the storage facility to prevent inadvertent use or access.

C12.3.5.6. Notifying the applicable emergency response and regulatory authorities of the change in the storage facility's use.

C12.3.5.7. Recording the date the storage facility was inspected, the name and position of the inspector, and the results in permanent real estate records.

C12.4. MINERAL EXPLORATION AND EXTRACTION

C12.4.1. Ammunition and Explosives Facilities

C12.4.1.1. Mineral exploration and drilling activities are to be separated from ammunition and explosives operating and storage facilities by public traffic route explosives safety distances provided there is to be no occupancy of the site by personnel when the exploration or drilling is completed, and by inhabited building explosives safety distances if occupancy is to continue when exploration or drilling is completed. If chemical agents or munitions are present, public exclusion distances must be maintained to the exploration or drilling activities. Examples of exploration activities are seismic or other geophysical tests. Examples of drilling activities are those for exploration or extraction of oil, gas, and geothermal energy.

C12.4.1.2. Mining activities are to be separated from ammunition and explosives operating and storage facilities by inhabited building explosives safety distances. If chemical agents or munitions are present, public exclusion distances must be maintained to the mining activities. Examples of mining activities are strip, shaft, open pit and placer mining, which normally require the presence of operating personnel.

C12.4.2. **Contaminated Lands.** Exploration, drilling, and mining are prohibited on the surface of explosives or chemical agent contaminated lands. Exploration and extraction is permitted by directional (slant) drilling at a depth greater than 50 feet beneath the explosives contaminated land surface or by shaft mining at a depth greater than 100 feet beneath such land surface.

C12.4.3. **Safety Review of Exploration and Extraction Plans.** Military Department approved plans for mineral exploration and extraction on land that is in proximity to ammunition and explosives facilities or land that is contaminated or suspected to be contaminated with explosives shall be forwarded to the DDESB for safety review and approval. Submission will include information necessary for explosives safety evaluation consistent with subsection C12.3.2., above. Relationships with other PES should be included.

C13. CHAPTER 13 MISHAP REPORTING AND INVESTIGATION REQUIREMENTS

C13.1. SCOPE

C13.1.1. The ammunition, explosives, and chemical agent mishaps that shall be reported and investigated in accordance with this Chapter are specified by enclosure 5 to DoD Instruction 6055.7 (reference (bb)). Mishap reports submitted to DDESB shall be prepared in accordance with implementing regulations to reference (bb). This reporting requirement has been assigned Report Control Symbol DD-A&T(AR)1020 in accordance with DoD 8910.1-M (reference (a)).

C13.1.2. This Chapter sets forth the minimum data to be included in all mishap reports submitted to the DDESB.

C13.1.3. Serious mishaps reported to the DDESB under this requirement need not be reported separately to the Director for Safety and Occupational Health, Office of the Deputy Under Secretary of Defense (Environmental Security) (ODUSD(E)) under the special reporting requirements of enclosure 3 to DoD Instruction 6055.7 (reference (bb)).

C13.2. REPORT CLASSIFICATION

Mishap reports should be unclassified whenever possible to ease appropriate issemination of useful safety information to DoD Components, industry, and allied governments.

C13.3. INITIAL REPORTS

C13.3.1. Telephonic and electrically transmitted reports shall be provided as soon as possible and shall include as much of the following data as may be immediately available.

C13.3.1.1. Name and location of the reporting activity.

C13.3.1.2. Name, title, and telephone number of person reporting, and of contact at the scene of the accident.

C13.3.1.3. Location of mishap (activity, city, installation, building number or designation, road names, or similar information).

C13.3.1.4. Item nomenclature (Mk, Mod, FSC, NIN, DODAC, or NALC).

C13.3.1.5. Quantity involved (number of items and NEW).

C13.3.1.6. Day, date, and local time of initial significant event and when discovered.

C13.3.1.7. Description of significant events (include type of operation involved).

C13.3.1.8. Number of fatalities (military, DoD civilian, or other civilian).

C13.3.1.9. Number of persons injured (military, DoD civilian, or other civilian).

C13.3.1.10. Description of material damage (government or nongovernment).

C13.3.1.11. Material damage cost (government or nongovernment).

C13.3.1.12. Cause.

C13.3.1.13. Action taken or planned (corrective, investigative, or EOD assistance).

C13.3.1.14. Effect on production, operation, mission, or other activity.

C13.3.1.15. Details of any remaining chemical agent hazard or contamination, if applicable.

C13.3.1.16. Are any news media aware (yes or no).

C13.3.2. Regardless of format, mishap reports prepared or received in compliance with other DoD Component regulatory documents may be used to satisfy these reporting requirements whenever they contain similar data.

C13.4. **FOLLOWUP REPORTS**

C13.4.1. Followup reports shall be submitted to the DDESB by way of priority-precedence, electrically-transmitted message within 2 workdays after notification of an occurrence has been received and shall contain any additional detailed information on the data elements contained in section C13.3., above.

C13.4.2. Regardless of format, supplemental mishap reports prepared or received in compliance with other DoD Component regulatory documents also may be used to satisfy the followup reporting requirement whenever they contain similar data.

C13.5. **INVESTIGATION REPORTS**

C13.5.1. **Event Circumstances.** The following data, as applicable, shall be included as a part of the mishap investigation reports. Chemical agent mishaps shall also require the inclusion of the data specified in section C13.6., below.

C13.5.1.1. Location, date, and local time.

C13.5.1.2. Type of operation or transportation mode engaged in at time of the mishap (include reference to applicable standing operating procedure or regulatory document).

C13.5.1.3. Description of mishap.

C13.5.1.4. Quantity, type, lot number, configuration, and packaging of ammunition, explosives, or chemical agents involved in mishap.

C13.5.1.5. Type of reaction or reactions.

C13.5.1.5.1. Single reaction, such as detonation, deflagration, fire,release, or activation.

C13.5.1.5.2. Multiple reaction, such as detonation and fire.

C13.5.1.5.3. Communication of reactions, such as fire caused fire, fire caused detonation, and detonation caused detonation, and the time between events.

C13.5.1.6. Possible or known causes.

C13.5.2. **Event Effects.** A copy of aerial and ground photographs taken of the mishap site shall be submitted to the DDESB as soon as possible after the occurrence. When appropriate, include photographs (color, whenever possible), maps, charts, and overlays, showing or listing the following data.

C13.5.2.1. Number of persons killed or injured (military, DoD civilian, or other civilian). Indicate cause of fatalities and injuries, and location of affected persons with respect to the mishap origin.

C13.5.2.2. Property damage at the mishap origin (government or nongovernment).

C13.5.2.3. Area containing property with complete destruction (more than 75 percent).

C13.5.2.4. Area containing property damage beyond economical repair (50 to 75 percent).

C13.5.2.5. Area containing repairable property damage (1 to 49 percent). Indicate event origin, and a description of the damage and its cause.

C13.5.2.6. Radii of uniform and of irregular glass breakage. When possible, include type and dimensions of glass broken at farthest point.

C13.5.2.7. Locations and dimensions of craters.

C13.5.2.8. Distances from the mishap origin at which direct propagation occurred, and whether from blast, fragments, or firebrands.

C13.5.2.9. Approximate number, size, and location of hazardous fragments and debris.

C13.5.3. **Factors Contributing to or Limiting Event Effects.** When appropriate, describe the influence of the following factors on the mishap:

C13.5.3.1. Environmental and meteorological, such as cloud cover, wind direction and velocity, temperature, relative humidity, electromagnetic radiation (EMR), and electrostatic buildup and/or discharge.

C13.5.3.2. Topography, such as hills, forests, and lakes.

C13.5.3.3. Structural features at the mishap origin, such as exterior and interior walls and bulkheads, roofs and overheads, doors and hatches, cells or magazines, earth cover, and barricades.

C13.5.3.4. Safety features, other than structural, at the mishap origin, such as remote controls, sprinkler or deluge systems, detectors, alarms, blast traps, and suppressive shielding.

C13.5.3.5. **Structures.** Position, orientation, and type of construction of all structures, damaged or not, located within maximum radius of damage. When either the applicable intermagazine, intraline, or inhabited building distances are greater than the radius of actual damage, show the location, orientation, and type construction of all structures situated within the Q-D radii.

C13.5.3.6. **Vessels, Vehicles, and Mobile Equipment.** Location within maximum radius of damage, or if the Q-D requirements are greater, location within the K9, K18, K24, and K30 Q-D radii.

C13.5.3.7. **Personnel.** Location within maximum radius of damage, or if the Q-D requirements are greater, location within the K9, K18, K40, and K50 Q-D radii.

C13.5.3.8. **Explosives, Ammunition, and Chemical Agents.** Location, type, configuration, amounts, and protection provided within maximum radius of damage, or if the Q-D requirements are greater, location within the applicable magazine and intraline radii.

C13.5.4. Analyses, conclusions, and recommendations.

C13.6. CHEMICAL AGENT MISHAPS

In addition to the data required by section C13.5., above, for ammunition and explosives mishaps, each chemical agent mishap investigation report shall contain the following information.

C13.6.1. **Injuries**

C13.6.1.1. The safety training that personnel received applicable to duty being performed at the time of the mishap.

C13.6.1.2. The availability, type, and use of protective equipment.

C13.6.1.3. A description of the emergency measures taken or performed by individuals at the scene of the mishap.

C13.6.1.4. A summary of applicable medical data.

C13.6.1.5. A sketch showing locations where disabling injuries occurred, and indicating the distance and direction from the agent source.

C13.6.2. **Mishap Area.** In addition to the environmental and meteorological data required by paragraph C13.5.3.1., above, indicate:

C13.6.2.1. The facility filter types and the facility ventilation and air turnover rates.

C13.6.2.2. The rate and manner of agent release and any other data used to determine the downwind hazard.

C13.6.2.3. The status and disposition of chemical agent remaining at the mishap.

C13.6.2.4. The details of any remaining chemical agent hazard and contamination, if applicable.

C14. CHAPTER 14 SPECIAL STORAGE PROCEDURES FOR WASTE MILITARY MUNITIONS

C14.1. SCOPE AND APPLICABILITY

C14.1.1. The Environmental Protection Agency (EPA) promulgated the Munitions Rule (MR) (62 FR 6621) (reference (cc)) to define when chemical and conventional military munitions become hazardous waste and to provide for the safe storage and transportation of such waste. The MR sets forth two approaches for the storage of waste military munitions: a conditional exemption (CE) from certain "Resource Conservation and Recovery Act (RCRA)" requirements and a new RCRA storage unit standard (i.e., Subpart EE, of Parts 264 and 265 of 40 CFR (reference (dd))).

C14.1.2. This Chapter establishes additional requirements for storage of waste military munitions.

C14.2. WAIVERS AND EXEMPTIONS

C14.2.1. **CE Storage.** Waivers and exemptions from this Standard are not authorized for ammunition and explosives storage facilities (ammunition storage units (ASUs)) storing CE waste military munitions.

C14.2.2. **RCRA Storage.** Waivers and exemptions from this Standard will only be available to units storing waste munitions under RCRA unit standards (e.g., Subpart EE of Part 264 of 40 CFR, (reference (dd))). However, after December 31, 1999, no unit used to store waste munitions shall be operated with a waiver or exemption from this Standard unless the approval authority (the Assistant Secretary of the Military Department responsible for safety, environment and installations) for all such waivers and exemptions has approved it. That authority may not be delegated.

C14.3. REQUIREMENTS FOR STORAGE OF WASTE MILITARY MUNITIONS UNDER CE

C14.3.1. The DOD Components shall ensure storing waste military munitions under CE must comply with 40 CFR Section 266.205(a) (reference (dd)). (Note: The MR established CE does not apply to chemical agents or chemical munitions.)

C14.3.2. The DOD Components shall ensure that installations and responsible activities:

C14.3.2.1. Maintain records of stored waste munitions for a minimum of 3 years from the date they were last stored. The records must be distinguished by type; a separate record or line item is required for each type of munition in any mixed lot of munitions received for storage. The record shall include the following:

C14.3.2.1.1. The type of waste military munitions stored by standard

nomenclature, Lot Number, Federal Supply Class (FSC), National Stock Number (NSN), Department of Defense Ammunition Code (DoDAC), and condition code.

C14.3.2.1.2. The quantity of waste military munitions stored.

C14.3.2.1.3. The date the munitions were identified as "waste."

C14.3.2.1.4. The date the munitions left storage.

C14.3.2.1.5. The storage location or locations (e.g., building number or storage pad, and grid coordinates) where they were stored.

C14.3.2.1.6. The means (e.g., destroyed, demilitarized, and shipped) and date of disposition of the munitions.

C14.3.2.1.7. When applicable, the sending and receiving sites for those waste military munitions received from or shipped to off-site sources.

C14.3.2.2. Physically separate (e.g., on a separate pallet or shelf; etc.) waste military munitions from nonwaste military munitions when both are stored in the same ASU.

C14.3.2.3. Clearly mark the physically separated waste military munitions to ensure proper identification.

C14.3.2.4. Store waste munitions under CE in ASUs that comply (without waiver or exemption) with the provisions of this standard. Each ASU storing waste military munitions or explosives under CE must be included in a DDESB-approved explosives safety site plan that the installation keeps on file. Those portions of the site plan addressing ASUs storing waste military munitions under CE shall be made available to applicable Federal or State environmental regulatory authority on request.

C14.3.2.5. Have Standard Operating Procedures (SOPs) or plans, under Chapter 8, section C8.6, above, which are designed to provide safety, security, and environmental protection. Those plans shall be coordinated with the applicable Federal, State, and local emergency response authorities (e.g., law enforcement, fire departments, and hospitals; etc.) and established planning committees.

C14.3.3. **Loss of CE**

C14.3.3.1. The unpermitted or uncontrolled detonation, release, discharge, or migration (e.g., loss or theft, or as a result of fire or explosion; etc.) of waste military munitions out of any storage unit that might endanger human health or the environment will result in the immediate loss of CE for those waste military munitions. Incidents of that nature and the loss of CE require reporting under section C14.5., below.

C14.3.3.2. The applicable Federal or State environmental regulatory authorities

may withdraw CE based on review or inspection of the installation's or responsible activity's compliance with the requirements for storage of waste military munitions under CE. The DoD Components may, at any time, restrict an activity from using CE. Additionally, the DDESB (or the DoD Components), upon discovery of a condition that could warrant loss of CE, shall report the condition to the applicable Component and to the commander of the installation or responsible activity.

C14.3.3.3. If CE is lost, the waste military munitions are subject to other RCRA hazardous waste regulations. The installation or responsible activities must obtain any required RCRA permits because of the loss of CE.

C14.3.3.4. Installations and responsible activities may apply for reinstatement of CE under 40 CFR Section 266.205(c) (reference (dd)).

C14.4. **OTHER STORAGE STANDARDS**

C14.4.1. The DoD Components shall forward to the Chair, DDESB, a copy of their Component-implementing standards or regulation pertaining to the storage of waste military munitions.

C14.4.2. Many States regulate waste management activities, including the storage of waste military munitions. If such State regulations conflict with DDESB or DoD Component explosives safety standards, the affected Component shall attempt to resolve the conflict. For those issues that cannot be resolved, the DoD Components shall notify the Chair, DDESB, through their Board member, of any irreconcilable conflict of State law, regulation, or directive with those or other DoD or Military Component explosives safety standards. The Chair, DDESB, shall review the law, regulation, or directive for any potential impact on explosives safety and will assist the DoD Component, in coordination with the Deputy Under Secretary of Defense (Environmental Security) (DUSD(ES)), in resolving such regulatory conflicts. Nothing in this section shall affect the Component's right to seek review of the State law, regulation, or directive in a court of competent jurisdiction.

C14.5. **REPORTING**

Besides other applicable reporting requirements, installations and responsible activities shall notify their chain of command, the DDESB Chair (through the DoD Component channels), the applicable Federal or State environmental regulatory authority, and established local committees, as follows:

C14.5.1. Telephonically or, in the case of the DoD Component and the DDESB, electronically (by e-mail message or facsimile and using the format specified in Chapter 13, above) within 24 hours from the time the installation or responsible activity becomes aware of any unpermitted or uncontrolled detonation, release, discharge, or migration of waste military munitions out of any storage unit (e.g., loss or theft, or as a result of fire or explosion; etc.) that may endanger human health or the environment; and

C14.5.2. In writing, if the initial report was telephonic, within 5 days from the time the installation or responsible activity becomes aware of any unpermitted or uncontrolled detonation, release, discharge, or migration of waste military munitions out of any storage unit (e.g., loss or theft, or as a result of fire or explosion; etc.) that may endanger human health or the environment. Follow-up reports to the DoD Component and the DDESB are only required when pertinent information, which was not previously reported, becomes known. Such reports, to include a report of investigation, shall comply with the requirements of Chapter 13.

C14.6. **CLOSURE OF FACILITIES STORING WASTE MUNITIONS UNDER CE**

C14.6.1. Besides the explosives safety requirements of Chapter 12:

C14.6.1.1. When an ASU that stored waste military munitions under CE is permanently taken out of service for the storage of nonwaste and waste military munitions, installations, and responsible activities shall ensure that such ASUs are applicably closed.

C14.6.1.2. Installations or responsible activities must notify the applicable Federal or State environmental regulatory authority in writing at least 45 days before the closure activities begin. Initiation of those closure procedures should occur within 180 days after the date the decision is made to permanently stop using the ASU for the storage of military munitions.

C14.6.1.3. On completion of closure activities, a "certification of closure," signed by the installation or responsible activity commander, or other equivalent level authority, and by an independent (i.e., an individual not assigned within the commander's or equivalent-level authority's chain of command) registered professional engineer must be submitted to the applicable Federal or State environmental regulatory authority within 90 days of completing the closure activities.

C14.6.1.4. The certificate of closure must state, at a minimum, that each of the explosives safety requirements in Chapter 12, subsection C12.3.5., above, shall have been met and that waste military munitions and residues are removed in such a manner as to protect the public and the environment consistent with the planned use of the ASU and of the property.

C14.6.1.5. If closure certification cannot be rendered, the installation or responsible activity must contact the applicable Federal and State environmental regulatory agency to determine the appropriate course of action.

C14.6.2. **Discontinuance of Use for the Storage of Waste Munitions.** When an ASU that stored waste military munitions under CE is permanently taken out of service for the storage of waste military munitions, but is to continue in service for the storage of nonwaste military munitions, installations and responsible activities shall ensure that waste military munitions and residues are removed.

C14.7. CLOSURE OF FACILITIES STORING WASTE MILITARY MUNITIONS UNDER RCRA (Subpart EE of Parts 264 and 265 of 40 CFR, reference (dd))

Besides those explosives safety requirements in Chapter 12, subsection C12.3.5, above, closure procedures for those sites operating under existing RCRA (Subpart EE of Parts 264 and 265 of 40 CFR, reference (dd)) permits shall follow those closure requirements stipulated in the respective permit.

AP1. APPENDIX 1 GLOSSARY

AP1.1. EXPLANATION OF TERMS

The following are descriptions of terms and phrases commonly used in conjunction with ammunition, explosives, and other dangerous materials. These are listed to provide a degree of uniformity of description in the use of technical information throughout these standards:

AP1.1.1. **Aboveground Magazines**. Any open area or any structure not meeting the requirements of an ECM that is used for explosives storage. (Revised by 321st Board)

AP1.1.2. **Action Level**. One-half of the exposure limit for a chemical agent averaged over an 8-hour work shift.

AP1.1.3. **Administration Area**. The area in which are located administrative buildings that function for the installation as a whole, excluding those offices located near and directly serving components of explosives storage and operating areas.

AP1.1.4. **Aircraft Passenger Transport Operations**. Passenger transport operations for the purpose of applying explosives Q-D tables are defined as follows: Passenger transport traffic involving military dependents and civilians other than those employed by or working directly for DoD Components. The following are not considered passenger transport operations.

AP1.1.4.1. Infrequent flights of base and command administrative aircraft that may, on occasion, provide some space available travel to authorized personnel.

AP1.1.4.2. Travel of direct hire appropriated funds personnel employed by any DoD Component.

AP1.1.4.3. Travel of such personnel as contractor and technical representatives traveling to or from direct support assignments at DoD installations.

AP1.1.5. **Ammunition and Explosives**. Includes (but is not necessarily limited to) all items of U.S.-titled (owned by the U.S. Government through DoD Components) ammunition; propellants, liquid and solid; pyrotechnics; high explosives; guided missiles; warheads; devices; devices, and chemical agent substances and components presenting real or potential hazards to life, property and the environment. Excluded are wholly inert items and nuclear warheads and devices, except for considerations of storage and stowage compatibility, blast, fire, and non-nuclear fragment hazards associated with the explosives.

AP1.1.6. **Ammunition and Explosives Aircraft Cargo Area**. Any area specifically designated for:

AP1.1.6.1. Aircraft loading or unloading of transportation configured ammunition and explosives.

AP1.1.6.2. Parking aircraft loaded with transportation configured ammunition and explosives.

AP1.1.7. **Ammunition and Explosives Area**. An area specifically designated and set aside from other portions of an installation for the development, manufacture, testing, maintenance, storage, or handling of ammunition and explosives.

AP1.1.8. **Ammunition Storage Unit (ASU).** All types of explosives storage magazines including outdoor or indoor, open storage areas, sheds, bunkers, and earth-covered and aboveground magazines.

AP1.1.9. **Anchorages**

AP1.1.9.1. **Scuttling Site**. An area of water specifically designated for positioning a ship for its flooding or sinking under emergency situations.

AP1.1.9.2. **Explosives Anchorage**. An area of water specifically designated for loading and unloading vessels and for anchoring vessels carrying a cargo of ammunition and explosives.

AP1.1.10. **Auxiliary Building**. Any building accessory to or maintained and operated to serve an operating building, line, plant, or pier area. Explosive materials are not present in an auxiliary building, such as powerplants and change houses, paint and solvent lockers, and similar facilities.

AP1.1.11. **Barge Piers**. Piers and wharfs used exclusively for loading/unloading explosives on barges or utility craft. (Approved at 320th Board Meeting)

AP1.1.12. **Barricade**. An intervening barrier, natural or artificial, of such type, size, and construction as to limit in a prescribed manner the effect of an explosion on nearby buildings or exposures.

AP1.1.13. **Blast Impulse**. The product of the overpressure from the blast wave of an explosion and the time during which it acts at a given point (that is, the area under the positive phase of the overpressure-time curve).

AP1.1.14. **Blast Overpressure**. The pressure, exceeding the ambient pressure, manifested in the shock wave of an explosion.

AP1.1.15. **Cavern Storage Site**. A natural cavern or former mining excavation adapted for the storage of ammunition and explosives.

AP1.1.16. **Ceiling Value**. The concentration of chemical agent that may not be exceeded for any period of time.

AP1.1.17. **Chamber Storage Site**. An excavated chamber or series of excavated chambers especially suited to the storage of ammunition an explosives. A cavern may be subdivided or otherwise structurally modified for use as a chamber storage site.

AP1.1.18. **Chemical Agent**. A substance that is intended for military use with lethal or incapacitating effects upon personnel through its chemical properties. Excluded from chemical agents for purposes of this Standard are riot control agents, chemical herbicides, smoke- and flame-producing items, and individual dissociated components of chemical agent ammunition.

AP1.1.19. **Chemical Munitions and Agents.** An agent or munition that through its chemical properties, produces lethal or other damaging effects to human beings, except that such term does not include riot control agents, chemical herbicides, smoke and other obscuration materials (40 CFR Section 266.201 and 50 USC Section 1521 (j) (1)) (references (dd) and (ee)).

AP1.1.20. **Classification Yard**. A railroad yard used for receiving, spatching, classifying, and switching of cars.

AP1.1.21. **Closure Block**. A protective construction feature designed to seal the entrance tunnel to an underground storage chamber in the event of an explosion within the chamber. Magae blocks are passive closures that are driven by the blast from a normally open to a closed position. Klotz blocks are active closures, operated by a hydraulic system to move from a normally closed to an open position (for access).

AP1.1.22. **Combat Aircraft Parking Area**. Any area specifically designated for:

AP1.1.22.1. Aircraft loading or unloading of combat-configured munitions.

AP1.1.22.2. Parking aircraft loaded with combat-configured munitions.

AP1.1.23. **Compatibility**. Ammunition or explosives are considered compatible if they may be stored or transported together without increasing significantly either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

AP1.1.24. **Conditional Exemption (CE).** An exemption from the regulatory definition of hazardous waste (and therefore from compliance with specific environmental requirements pertaining to the storage of hazardous waste) conditioned on compliance with certain criteria requirements,as in 40 CFR Section 266.205 (reference (dd)).

AP1.1.25. **Connected-Chamber Storage Site**. A chamber storage site consisting of two or more chambers connected by ducts or passageways. Such chambers may be at the ends of branch tunnels off a main passageway.

AP1.1.26. **Controlling Authority**. The headquarters of the DoD Component concerned.

AP1.1.27. **Debris**. Any solid particle thrown by an explosion or other strong energetic reaction. For aboveground detonations, debris usually refers to secondary fragments. For underground storage facilities, debris refers to both primary and secondary fragments, which are transported by a strong flow of detonation gasses.

AP1.1.28. **Debris Trap**. A protective construction feature in an underground storage facility which is designed to capture fragments and debris from a detonation within the facility. This is usually accomplished by using the inertia of the material to separate it from the detonation gas stream. (Illustrated in Figure C9.F3.)

AP1.1.29. **Deflagration**. A rapid chemical reaction in which the output of heat is enough to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction and temperature, and may cause transition into a detonation.

AP1.1.30. **Designated Aircraft Parking Area**. An aircraft parking area that meets airfield parking criteria. (Approved by correspondence 14 August 2001)

AP1.1.31. **Detonation**. A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction which proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium forming a propagating shock wave that originally is of supersonic velocity. A detonation, when the material is located on or near the surface of the ground, is characterized normally by a crater.

AP1.1.32. **Dividing Wall**. A wall designed to prevent, control, or delay propagation of an explosion between quantities of explosives on opposite sides of the wall.

AP1.1.33. **DoD Mishap**. An unplanned event or series of events that result in damage to DoD property, occupational illness to DoD military or civilian personnel, injury to DoD military personnel on or off duty, injury to on-duty civilian personnel; damage to public and private property, or injury and illness to non-DoD personnel as a result of DoD operations.

AP1.1.34. **Dolphin**. A mooring post or posts on a wharf or quay.

AP1.1.35. **Donor/Acceptor**. A total quantity of stored ammunition may be subdivided into separate storage units in order to reduce the MCE, and, consequently, the Q-D of an accidental detonation. The separation distances, with or without an intervening barrier, should be sufficient to ensure that a detonation does not propagate from one unit to another. For convenience the storage unit which detonates is termed the donor, and nearby units, which may be endangered, are termed acceptors. The locations of the donor and acceptor define the PES and ES, respectively.

AP1.1.36. **Earth-Covered Magazine (ECM)**. Any earth-covered structure that meets soil cover depth and soil requirements of C5.3. ECM have three possible structural strength designations ("7-Bar", 3-Bar", or "Undefined"). The strength of an ECM's headwall and door(s) determines its designation.

AP.1.37. **Energetic Liquid.** A liquid, slurry, or gel, consisting of or containing an explosive, oxidizer, fuel, or combination of the above, that may undergo, contribute to, or cause rapid exothermic decomposition, deflagration, or detonation.

AP1.1.38. **Engineering Controls**. Regulation of facility operations through the use of prudent engineering principles, such as facility design, operation sequencing, equipment selection, and process limitations.

AP1.1.39. **Expansion Chamber**. A protective construction feature in an underground storage facility which is designed to reduce the blast shock and overpressure exiting the facility by increasing the total volume of the complex. It may also function as an operating area within the underground facility, as well as a debris trap. (Illustrated in Figure C9.F3.)

AP1.1.40. **Explosion**. A chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition releasing large volumes of highly heated gases that exert pressure on the surrounding medium. Also, a mechanical reaction in which failure of the container causes the sudden release of pressure from within a pressure vessel, for example, pressure rupture of a steam boiler. Depending on the rate of energy release, an explosion can be categorized as a deflagration, a detonation, or pressure rupture.

AP1.1.41. **Explosives Facility**. Any structure or location containing ammunition and explosives excluding combat aircraft parking areas or ammunition and explosives aircraft cargo areas.

AP1.1.42. **Exposed Site (ES)**. A location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosion site (PES). The distance to a PES and the level of protection required for an ES determine the quantity of ammunition or explosives permitted in a PES.

AP1.1.43. **Explosives Sited Aircraft Parking Area**. An aircraft parking area that meets both explosives safety and airfield criteria. (Approved by correspondence 14 Aug 2001)

AP1.1.44. **Forward Arming and Refueling Point (FARP).** A temporary facility, organized, equipped and deployed by an aviation commander, and normally located in the main battle area closer to the area of operation than the aviation unit's combat service area, to provide fuel and ammunition necessary for the employment of aviation maneuver units in combat. The FARP permits combat aircraft to rapidly refuel and rearm.

AP1.1.45. **Firebrand**. A projected burning or hot fragment whose thermal energy is transferred to a receptor.

AP1.1.46. **Fragmentation**. The breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place. Fragments may be complete items, subassemblies, pieces thereof, or pieces of equipment or buildings containing the items.

AP1.1.47. **General Public**: Persons not associated with DoD installation's mission or operations such as visitors, to include guests of personnel assigned to the installation, or persons not employed or contracted by DoD or the installation. (Approved change by correspondence July 5, 2000)

AP1.1.48. **Hardened Aircraft Shelter**. Defined as being one of the following structure types.

AP1.1.48.1. First Generation (TAB VEE). A semicircular arch with a 24-foot radius, a prow-shaped front closure, and either a recessed vertically-hinged door (regular TAB VEE) or a laterally-opening external flush door (modified TAB VEE). Dimensions are approximately 48 feet wide by 100.8 feet long.

AP1.1.48.2. First Generation (TAB VEE) Flow Through with Door. A semicircular arch with a 24-foot radius, prow-shaped front and rear closures, and either two recessed vertically-hinged doors (regular TAB VEE) or two laterally-opening external flush doors (modified TAB VEE). Dimensions are approximately 49 feet wide by 100.8 feet long.

AP1.1.48.3. First Generation (TAB VEE) Flow-Through without Door. A semicircular arch with a 24-foot radius. They are open at the front and rear. Dimensions are approximately 48 feet wide by 100.8 feet long.

AP1.1.48.4. Korean TAB VEE. A semicircular arch with a 24-foot radius, an exhaust port in the rear wall protected only by a blast defector, and an open front. Dimensions are approximately 48 feet wide by 100.8 feet long

AP1.1.48.5. Second Generation. A 29.4-foot double-radius pseudo-elliptical arch, a vertical reinforced concrete panel, and a sliding external laterally-opening flush door. Dimensions are approximately 82 feet wide by 124 feet long.

AP1.1.48.6. Third Generation. A 27.4-foot double-radius pseudo-elliptical arch, a vertical, reinforced concrete panel, a sliding external laterally-opening flush door, and a barricaded personnel door on one side. Dimensions are approximately 70.8 feet wide by 120 feet long.

AP1.1.48.7. Third Generation, Flow-Through with Doors. A 27.4-foot double-radius pseudo-elliptical arch, a vertical reinforced concrete panel, sliding external laterally-opening flush doors at the front and rear, and a barricaded personnel door on one side. Dimensions are approximately 70.9 feet wide by 120 feet long.

AP1.1.48.8. Third Generation, Flow-Through (Korean Flow-Through) without

Doors. A 27.4-foot double-radius pseudo-elliptical arch and an unprotected front and rear. Dimensions are approximately 70.8 feet wide by 120 feet long.

AP1.1.49. **Hazardous Fragment**. A hazardous fragment is one having an impact energy of 58 ft-lb or greater.

AP1.1.50. **Hazardous Fragment Density**. A density of hazardous fragments exceeding one per 600 sq. ft.

AP1.1.51. **Heavy Armor.** Main battle tanks or other vehicles that are expected to contain fragments and reduce blastover pressure generated from a detonation of ammunition contained internally.

AP1.1.52. **High Explosive Equivalent or Explosive Equivalent**. The amount of a standard explosive that, when detonated, will produce a blast effect comparable to that which results at the same distances from the detonation or explosion of a given amount of the material or which performance is being evaluated. It usually is expressed as a percentage of the total net weight of all reactive materials contained in the item or system. For the purpose of these standards, TNT is used for comparison.

AP1.1.53. **Holding Yard**. A location for groups of railcars, trucks, or trailers used to hold ammunition, explosives, and dangerous materials for interim periods before storage or shipment.

AP1.1.54. **Hybrid Propellants.** A propellant charge utilizing a combination of physically separated solid and liquid (or gelled) substances as fuel and oxidizer. (Changed by correspondence 2 November 2000)

AP1.1.55. **Hygroscopic**. A tendency of material to absorb moisture from its surroundings.

AP1.1.56. **Hypergolic**. A property of various combinations of chemical to self ignite upon contact with each other without a spark or other external initiation.

AP1.1.57. **Inhabited Buildings**. Buildings or structures, other than operating buildings occupied in whole or in part by human beings, both within and outside DoD establishments. They include but are not limited to schools, churches, residences (quarters), Service clubs, aircraft passenger terminals, stores, shops, factories, hospitals, theaters, mess halls, post offices, and post exchanges.

AP1.1.58. **Inspection Station**. A designated location at which trucks and railcars containing ammunition and explosives are inspected.

AP1.1.59. **Installation Related Personnel**: Military personnel (to include family members), DoD employees, DoD contractor personnel, and other personnel having either a direct

operational (military or other Federal personnel undergoing training at an installation) or logistical support (e.g., vendors) relationship with installation activities. (Changed by correspondence 5 July 2000)

AP1.1.60. **Interchange Yard**. An area set aside for the exchange of railroad cars or vehicles between the common carrier and DoD activities.

AP1.1.61. **Intraline Distance**. The distance to be maintained between any two operating buildings and sites within an operating line, of which at least one contains or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building may be not less than the intraline distance required for the quantity of explosives contained in the service magazine.

AP1.1.62. **Joint DoD - Non-DoD Use Runway/Taxiway**. A runway and/or taxiway serving both DoD and commercial aircraft. A runway and/or taxiway serving solely DoD, chartered, or Non-DoD aircraft on DoD authorized business is not joint use.

AP1.1.63. **K-factor.** The factor in the formula $D=KW^{1/3}$ used in quantity-distance determinations where D represents distance in feet and W is the net explosive weight in pounds. The K-factor is a constant and represents the degree of damage that is acceptable. Typical constants range from 1.25 to 50; the lower the factor, the greater the damage that is accepted.

AP1.1.64. **Launch Pads**. The load-bearing base, apron, or platform upon which a rocket, missile, or space vehicle and its launcher rest during launching.

AP1.1.65. **Light Armor.** Armored vehicles that are not expected to contain the fragments or overpressure of a detonation of the internally stored ammunition, however the armor does give protection from an external detonation. For example, M113 series vehicles are considered light armor.

AP1.1.66. **Liquid Propellants**. Substances in fluid form (including cryogenics) used for propulsion or operating power for missiles, rockets, ammunition and other related devices (See Table C9.T17.). For purposes of this standard, liquid fuels and oxidizers are considered propellants even when stored and handled separately.

AP1.1.67. **Loading Density**. Quantity of explosive per unit volume. usually expressed as either pounds per cubic foot (lbs/ft^3). As applied to underground storage facilities, there are two types of loading densities used in Q-D calculations:

AP1.1.67.1. Chamber loading density is based on the NEW within an individual storage chamber and the volume of the chamber (V_{CH}).

AP1.1.67.2. The calculation of air blast peak pressures and lBD's for explosions in underground storage facilities is based on the shock-engulfed volume (V_E) of the facility. This is the total volume filled by the expanding gases at the time the blast front reaches the point of interest (e.g., the entrance to an adjacent chamber). It includes volumes in any direction that

the gases can enter, to a distance from the explosion source that equals the distance from the source to the point of interest. For IBD, the point of interest is the tunnel opening.

AP1.1.68. **Loading Docks**. Facilities, structures, or paved areas, designed and installed for transferring ammunition and explosives between any two modes of transportation.

AP1.1.69. **Lunchrooms**. Facilities where food is prepared or brought for distribution by food service personnel. It may serve more than one PES. A breakroom in an operating building may be used by personnel assigned to the PES to eat meals.

AP1.1.70. **Magazine**. Any building or structure, except an operating building, used for the storage of ammunition and explosives.

AP1.1.71. **Marshalling Yard**. A port, point or location away from the congestion of a port facility where a unit or activity accounts for or assembles all their equipment and prepares for onward movement.

AP1.1.72. **Mass-Detonating Explosives**. HE, black powder, certain propellants, certain pyrotechnics, and other similar explosives, alone or in combination, or loaded into various types of ammunition or containers, most of the entire quantity of which can be expected to explode virtually instantaneously when a small portion is subjected to fire, to severe concussion or impact, to the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without. Such an explosion normally will cause severe structural damage to adjacent objects. Explosion propagation may occur immediately to other items of ammunition and explosives stored sufficiently close to and not adequately protected from the initially exploding pile with a time interval short enough so that two or more quantities must be considered as one for Q-D purposes.

AP1.1.73. **Maximum Credible Event (MCE)**

AP1.1.73.1. **General**. In hazards evaluation, the MCE from a hypothesized accidental explosion, fire, or agent release is the worst single event that is likely to occur from a given quantity and disposition of ammunition and explosives. The event must be realistic with a reasonable probability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

AP1.1.73.2. **Chemical Agent**. An MCE for a chemical agent is defined as the hypothesized maximum quantity of agent that could be released from an ammunition item (without explosives), bulk container, or process as a result of a single unintended, unplanned, or accidental occurrence. It must be realistic with a reasonable probability of occurrence.

AP1.1.74. **Module**. A barricaded area comprised of a series of connected cells with hard surface storage pads separated from each other by barricades.

AP1.1.75. **Military Munitions.** All ammunition products and components produced or used by or for the U.S. Department of Defense or the U.S. Armed Services for national defense and security, including military munitions under the control of the Department of Defense, the U.S. Coast Guard, the U.S. Department of Energy, and the National Guard personnel. The term "military munitions" includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries used by the DoD Components, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. "Military munitions" do not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components thereof. However, that term does include non-nuclear components of nuclear devices, managed under the DoE's nuclear weapons program, after all required sanitizing operations under the "Atomic Energy Act of 1954," as amended, have been completed (40 CFR Section 260.10, reference (dd)).

AP1.1.76. **Navigable Streams**. Those parts of streams, channels, or canals capable of being used in their ordinary or maintained condition as highways of commerce over which trade and travel are or may be conducted in the customary modes, not including streams that are not capable of navigation by barges, tugboats, and other large vessels unless they are used extensively and regularly for the operation of pleasure boats.

AP1.1.77. **NEQ**. Net explosive quantity expressed in kilograms.

AP1.1.78. **NEW**. Net explosive weight expressed in pounds.

AP1.1.79. **Nitrogen Padding (or Blanket)**. Used to fill the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical contained therein and to avoid formation of a flammable mixture, or to maintain a nitrogen atmosphere in or around an operation or piece of equipment.

AP1.1.80. **Non-DoD Components**. Any entity (government, private, or corporate) that is not a part of the Department of Defense.

AP1.1.81. **Operating Building**. Any structure, except a magazine, in which operations pertaining to manufacturing, processing, handling, loading, or assembling of ammunition and explosives are performed.

AP1.1.82. **Operating Line**. A group of buildings, facilities, or related work stations so arranged as to permit performance of the consecutive steps in the manufacture of an explosive, or in the loading, assembly, modification, and maintenance of ammunition.

AP1.1.83. **Operational Shield**. A barrier constructed at a particular location or around a particular machine or operating station to protect personnel, material, or equipment from the effects of a possible localized fire or explosion.

AP1.1.84. **Passenger Railroad**. Any steam, diesel, electric, or other railroad which carries passengers for hire.

AP1.1.85. **PEL**. The maximum time-weighted average airborne concentration (milligrams per cubic meter) of a chemical agent to which it is believed that essentially all members of a specific population can be exposed for a specific period without adverse effect.

AP1.1.86. **PES**. The location of a quantity of explosives that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents. Quantity limits for ammunition and explosives at a PES are determined by the distance to an ES.

AP1.1.87. **Pier**. A landing place or platform built into the water, perpendicular or oblique to the shore, for the berthing of vessels.

AP1.1.88. **Prohibited Area**. A specifically designated area at airfields, seadromes, or heliports in which all ammunition and explosives facilities are prohibited.

AP1.1.89. **Public Access Exclusion Distance**. The distance arc (calculated) from the agent source at which no more than 10.0, 4.3, and 150 milligrams per minute per cubic meter is present for GB, VX, and mustard, respectively.

AP1.1.90. **Public Traffic Route**. Any public street, road, highway, navigable stream, or passenger railroad (includes roads on a military reservation that are used routinely by the general public for through traffic).

AP1.1.91. **Q-D**. The quantity of explosive material and distance separation relationships that provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q-D tables. Separation distances are not absolute safe distances but are relative protective or safe distances. Greater distances than those shown in the tables shall be used whenever practicable.

AP1.1.92. **Quay**. A marginal wharf or solid fill.

AP1.1.93. **Ready ammunition storage.** A location where ammunition is stored for near term tactical or training use. Generally, ready ammunition storage locations will supply one or more armament pads.

AP1.1.94. **Risk**. The product of the probability or frequency an accident will occur within a certain time and the accident's consequences to people, property or the environment.

AP1.1.95. **Robust Munitions**. These are munitions that meet two of the following three criteria: (1) have a ratio of the explosive weight to empty case weight less than 1.00, (2) have a nominal wall thickness of at least 0.4 inches, and (3) have a case thickness/$NEW^{1/3}$ > 0.05 in/$lb^{1/3}$. The following cartridges are, by definition, robust: 20mm, 25 mm, and 30mm. Other

examples of robust ammunition include MK 80 series bombs, M107 projectiles, Tomahawk and Harpoon penetration warheads. (Changed at 319th Board Meeting)

AP1.1.96. **Rock Strength**. Strong, moderately strong, and weak rock are designators which provide a general classification of rock types for siting underground storage facilities for ground shock hazards. Classification of a rock body into one of these three rankings is based on the rock impedance factor:

rock impedance factor = $\rho \cdot c \cdot 10^{-6}$
and $\rho = \gamma/g$
where
γ is the rock density, lbs/ft^3
g is the gravitational acceleration, ft/sec^2
ρ is the mass density of the rock, lbs-sec^2/ft^4
c seismic velocity of the rock, ft/sec.

AP1.1.96.1. The rock impedance factor will be 0.75 or more for strong rock; between 0.75 and 0.5 for moderately strong rock; and less than 0.5 for weak rock.

AP1.1.96.2. Values of these parameters can usually be estimated based on examinations of exposed rock outcrops or core samples from an exploratory drill hole. For the detailed design of an underground storage facility (maximum span width, rock reinforcement, etc.), standard rock mechanics classification systems should be used.

AP1.1.97. **Runway**. Any surface on land designated for aircraft takeoff and landing operations, or a designated lane of water for takeoff and landing operations of seaplanes.

(Added by 322nd Board Meeting)

AP1.1.98. **Secure Explosives Holding Area**. An area designated for the temporary parking of commercial carriers' motor vehicles transporting DoD-owned Arms, Ammunition, and Explosives (AA&E). (See Part 205 of reference (ar)).

(Added by 322nd Board Meeting)

AP.1.1.99. **Secure Non-explosives Holding Area**. An area designated for the temporary parking of commercial carriers' motor vehicles transporting Categorized DoD Arms, classified (SECRET or CONFIDENTIAL) materials, and Controlled Cryptographic Items (CCI). (See Part 205 of reference (ar)).

AP1.1.100. **Service Magazine**. A building of an operating line used for the intermediate storage of explosives materials.

AP1.1.101. **Ship or Barge Units**. All explosives within a line encompassing the ship or barge being loaded, the space on the pier for spotting of freight cars and trucks, and the space in the water for barges which may be working the ship or barge.

AP1.1.102. **Single-Chamber Storage Site**. An excavated chamber with its own access to the natural ground surface, not connected to any other storage chamber.

AP1.1.103. **Source Emission Limits**. The amount of chemical agent that may be released at a particular point that allows for natural dilution, ventilation, and meteorological conditions interfacing.

AP1.1.104. **Spall**. Spall refers to pieces of a material (and the process by which they are formed) that are broken loose from the surface of a parent body by tensile forces that are created when a compression shock wave travels through the body and reflects from the surface. For underground storage, spall normally refers to the rock broken loose from the wall of an acceptor chamber by the shock wave transmitted through the rock from an explosion in a nearby donor chamber.

AP1.1.105. **Static missile battery.** Deployed ground-based missiles meant to be employed in a non-mobile mission for offensive or defensive purposes.

AP1.1.106. **Static Test Stand**. Locations on which liquid propellant engines or solid propellant motors are tested in place.

AP1.1.107. **Support Facilities**. Ammunition and explosives storage or operations that support solely the functions of tactical or using units as distinguished from storage depots or manufacturing facilities.

AP1.1.108. **Suspect Truck and Car Site**. A designated location for placing trucks and railcars containing ammunition or explosives that are suspected of being in a hazardous condition. These sites are also used for trucks and railcars that may be in a condition that is hazardous to their contents.

AP1.1.109. **Tactical Facilities**. Tactical facilities are prepared locations with an assigned combat mission, such as missile launch facilities, alert aircraft parking areas, or fixed gun positions.

AP1.1.110. **Taxiway or Taxilane**. Any surface designated as such in the basic airfield clearance criteria specified by a DoD Component publication or Federal Aviation Regulation (reference (q)).

AP1.1.111. **Toxic Area**. A defined area in which CG K ammunition or Class 6 chemical agents are handled or stored.

AP1.1.112. **Ufer Ground**. A Ufer Ground is an earth electrode system which consists of solid conductors encased along the bottom of a concrete foundation footing or floor in direct contact with earth.

AP1.1.113. **Unexploded Ordnance.** Explosive ordnance which has been primed, fuzed, armed or otherwise prepared for action, and which has been fired, dropped, launched, projected

or placed in such a manner as to constitute a hazard to operations, installations, personnel or material an remains unexploded either by malfunction or design or for any other cause.

AP1.1.114. **Unit Risk**. The risk to personnel and/or facilities that is associated with debris, fragment and/or blast hazards that is the result of the detonation of a single round of ammunition.

AP1.1.115. **Waste Military Munition.** Military munitions are waste when they are solid or hazardous waste under the regulations (42 U.S.C. 9601, et seq., reference (ff)) implementing the Resource Conservation and Recovery Act (RCRA) Subpart EE of Part 264 of 40 CFR, reference (dd), or defined as a waste under a DoD Component's written procedures. Waste military munitions are defined in Section 266.202 of 40 CFR, reference (dd). (**Note**: Decisions about whether specific munitions are or are not waste should be made with reference to Section 260.10 and Sections 266.200 through 266.206 of 40 CFR, reference (dd)).

AP1.1.113.1. An unused military munition is a solid waste when any of the following occurs:

AP1.1.113.1.1. The munition is abandoned by being disposed of, burned, detonated (except during intended use), incinerated, or treated before disposal;

AP1.1.113.1.2. The munition is removed from storage in a military magazine or other storage area for the purpose of being disposed of, burned, or incinerated, or treated prior to disposal;

AP1.1.113.1.3. The munition is deteriorated or damaged (e.g., the integrity of the munition is compromised by cracks, leaks, or other damage) to the point that it cannot be put into serviceable condition, and cannot reasonably be recycled or used for other purposes; or,

AP1.1.113.1.4. An authorized military official has declared the munition a solid waste. (**Note**: Declaration by an "authorized military official" that munitions are waste (Section 266.202(b)(4) of 40 CFR, reference (dd)) has a very limited meaning and applicability. The only example is a declaration by the Army in 1984 that M55 rockets are waste. The Environmental Protection Agency expects that such a declaration would be in writing. A decision that munitions are unserviceable, or that they are to be transferred into a demilitarization account does not, by itself, constitute a decision that the munitions are solid waste.)

AP1.1.113.2. A used or fired military munition is a solid waste, if as follows:

AP1.1.113.2.1. When transported off range or from the site of use, where the site of use is not a range, for the purposes of storage, reclamation, treatment, disposal, or treatment before disposal; or,

AP1.1.113.2.2. If recovered, collected, and then disposed of by burial, or land filling either on or off a range.

AP1.1.113.3. For the RCRA (Section 1004(27) of reference (dd)), a used or fired military munition is a solid waste, and, therefore, is potentially subject to RCRA corrective action authorities under Section 3004(u) and 3004(v), and 3008 (h) of reference (dd), or, imminent and substantial endangerment authorities under Section 7003, of reference (dd) if the munition lands off-range and is not promptly rendered safe and/or retrieved. Any imminent and substantial threats associated with any remaining material must be addressed. If remedial action is not possible, the operator of the range must maintain a record of the event for as long as any threat remains. The record must include the type of munition and its location (to the extent the location is known). (For further clarification see 40 CFR Section 266.202 of reference (dd) under "Definition of Solid Waste.")

AP1.1.114. **Wharf**. A landing place or platform built into the water or along the shore for the berthing of vessels.

AP1.1.115. **Wharf Yard**. A yard that is close to piers or wharves in which railcars or trucks are held for short periods of time before delivery to the piers or wharves.